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NAME OF AUTHOR   Barbara Klein

TITLE OF THESIS   An Examination of Cross-Modal Transfer in Hearing and Hearing-Impaired Children

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AN EXAMINATION OF CROSS-MODAL TRANSFER IN HEARING

AND HEARING-IMPAIRED CHILDREN

by

Ⓒ BARBARA KLEIN

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and
recommend to the Faculty of Graduate Studies and Research,
for acceptance, a thesis entitled "An Examination of
Cross-Modal Transfer in Hearing and Hearing-Impaired
Children," submitted by Barbara Klein in partial fulfil-
ment of the requirements for the degree of Master of
Education in Educational Psychology.

ABSTRACT

It was hypothesized than an inability to perceive
auditory stimuli is cause for difficulty in perceptual
processing of certain sensory information. Sixty-six
hearing impaired and normal-hearing subjects were tested
on intra-modal, intra-condition, cross-modal and cross-
condition transfer problems. Mean total correct responses
to the problems were compared between and within the groups
of normal hearing and hearing-impaired subjects. Hearing
subjects produced significantly more correct responses
than deaf subjects on cross-modal and modality-incongruent
tasks. As expected, no differences between groups were
found when tasks involved stimulus distributions in which
both groups were equally experienced. It was concluded
that the poorer performance of the hearing-impaired sub-
jects could in part account for their linguistic and
reading difficulties when they are taught in a traditional
manner.

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CHAPTER I

INTRODUCTION

Background

In recent years, a great deal of literature con-
cerning the phenomenon of cross-modal transfer has been
accumulated.

A simplistic description of this phenomenon is
provided by Blank and Bridger (1964) as, ". . . the use of
information acquired through one sense modality in solving
problems presented in another modality." The factors
involved in cross-modal transfer have been examined for
various purposes, some of them heuristic. Most of the
studies related to this subject have centered around find-
ing instances in which the phenomenon occurs, how it occurs
and why some modes of presentation are more amenable to its
occurance than others. Among the studies most relevant to
education are those conducted by Birch and Belmont (1964)
that have related the inability to transfer and integrate
information across modalities to reading retardation.

This thesis will present an explanation for the
unusually large proportion of reading retardation among
the deaf population (Vernon, 1970).

The correlates of reading retardation are of
particular concern. The often stated reason for

this retardation is language deficiency. But language learning for the school-aged deaf child is based on reading, in which case a more legitimate problem to explore would seem to be the correlates of reading retardation that result in perhaps concommitant linguistic deficiency.

Reading has been characterized by educators as a process involving transfer from visual-spatial symbols to auditory-temporal equivalents. The underlying assumption of this characterization supposes that the language upon which reading is based is auditorally acquired. This assumption is easily appreciated when one is considering teaching reading to a child whose hearing is unimpaired and has, in fact, an auditory language foundation. For such a child, reading is to a large extent a cross-modal transfer performance. For a hearing child, the inability to integrate information across modalities may be the result of inadequate experience with such tasks (Gibson, 1969). However, we are concerned here with an explanation of reading retardation among the deaf.

The language base for the deaf child is visual. This is demonstrated in O'Connor and Hermelin's study of sensory deprivation (1971) which reveals that when a modality of input is restricted, stimuli specific to the non-functional modality are not likely to be coded, especially in the fashion dominant for that modality, e.g. temporal. In other words the deaf child will tend not to

process temporal inputs, or may try to convert them since they are specific to only the auditory and tactile modalities. The deaf child learns language visually. If language is visually-based for the deaf and the components of reading are visual-spatial stimuli, then the problem of learning to read is one that is intramodal and not cross-modal and perhaps rather easy. Reading remains a transfer task, but a transfer from concrete objects, spatially distributed to written words, also spatially distributed.

The significance of this paradigm will become clear when we consider the prevailing method of reading instruction for the deaf. When young deaf children are given language training, there is usually a conterminous introduction to reading (McGinnis Method, Tracy Clinic Handbook). Sounds are broken down into phonemes and later combined into sequences. The child is expected to "read the lips" as well as to focus his attention on visible vocal operations (e.g., movements of the jaw), distinguishing facial expressions. Tactile responses are also expected (such as feeling the vibrations of his vocal folds). The child is then expected to integrate and "understand" a sequential arrangement of all these stimuli. Furthermore, the child is then required to use the information he has acquired from this training procedure and reproduce it motorically (involving another modality).

Some investigators (Blank & Bridger, 1964) were unable to elicit cross-modal transfer responses in their

younger subjects. Yet many educators and parents expect
the deaf child to not only interpret a temporal sequence
through a visual modality, but to transfer whatever infor-
mation is being processed to a motoric modality. Not one,
but many visual stimuli are presented. This seemingly
impossible task is compounded when the child reaches
school age and must begin learning how to "read."

Reading thus becomes another transfer problem.
Visual temporally presented stimuli (lip-reading) are
associated with visual stimuli that are spatially distri-
buted. All temporal stimuli are expected to be assimi-
lated, processed and transferred to a visual image (a
word) and transferred across modalities again to be
verbalized. Another dimension to this instructional pro-
cedure involves not only processing these stimuli to be
stored, but processing them for meaning. Beyond the fact
that verbal associations to visual stimuli are expected
to be established, the child must be able to identify the
word, or visual stimulus, meaningfully; i.e., to recognize
its associated concrete object.

Learning to read for the deaf child is a phenom-
enon so much more complex than it is for his hearing peers
that retarded reading and linguistic deficiency would seem
to be accomplishments in themselves.

Statement of the Problem

This thesis maintains that linguistic and reading ability for the deaf are one and the same; that competence in both is predicated upon the ability to process perceptual information. The perceptual process with which this study is concerned is the coding of information presented either spatially or temporally within or between different sensory modalities.

Past research suggests that a sensory deficit will impede an individual's performance at the coding and integration of sensory input. This thesis proposes that a sensory deficit such as deafness restricts individuals to the intact sensory modalities for the reception of information to be coded and processed, thus precluding them from experiences available to persons not sensorily deprived. Therefore, facility in cortical processing of sensory information is a function of experience with such information.

Until a plausible explanation of reading retardation among the deaf can be determined, research designed to modify instructional strategies or presentation modality will not be soundly based. The review of the literature (Chapter II) is focused on possible determinants of reading retardation among the pre-lingually deaf population. This examination will be concerned with the perceptual facets of the problem as opposed to the linguistic considerations--although both are significant.

The responses of deaf and hearing children to different modalities and conditions of stimuli for presentation and transfer were evaluated. The optimum presentation and response modalities were determined by a testing procedure involving various modalities and conditions in combination. The findings of the study generated suggestions for alternative methods of instruction and language acquisition for the congenitally deaf child.

CHAPTER II

THEORETICAL AND METHODOLOGICAL BACKGROUND

A Theoretical View: Language and Its
Relation to Simultaneous and
Successive Processing

While language probably does not function as a
mediator in cross-modal operations (to be explicated in
the section on mediation), language is a phenomenon which
to a great extent is dependent on cross-modal and simul-
taneous and successive information processing (Hermelin &
O'Connor, 1970). As Lashley (1960) so aptly informs us,
linguistic performance, including verbal responses and
syntactical arrangements of language units, is not a
manifestation of structuring which is inherent to the
language system. Language performance is, rather, a conse-
quence of a potential characteristic to human beings; i.e.,
the ability we have to arrange linguistic components into
a particular kind of serial order, to perceive such arrange-
ments and otherwise carry out the necessary integration of
stimuli across modes for either the delivery or reception
of linguistic forms.

Since we owe a significant degree of our under-
standing of the integrative activities of the cerebral

cortex to A. R. Luria, it is appropriate to begin a dis-
cussion, concerning the relation of these activities to
the phenomenon of language, with this renowned Soviet
psychologist. In The Human Brain and Psychological
Processes (1966), Luria has provided a division of inte-
grative activity into the two forms introduced by I. M.
Sechenov in 1878. These two forms of integration are
simultaneous and successive synthesis. Luria related his
observation that simultaneous and successive synthesis
appear to occur at three different increasing levels of
complexity in human behavior, which he designated as the
(1) perceptual, (2) mnestic and (3) intellectual levels
of operations.

Beginning with an example of an instance of simul-
taneous processing at the perceptual level, Luria remarked
that when glancing at a complicated picture, although one
tends to examine the parts gradually, distinguishing the
essential elements, ". . . we synthesize them into a single
entity, a unified visual structure [p. 74]." Analogously,
stimuli felt by the hand are explored consecutively but
are integrated into a simultaneous scheme when processed
by the brain, and are then rendered as a unified image.
Similar processes of synthesis were noted to take place in
the acoustic analyzer for example, in the form of chords.

Such synthesis is equally evident at the mnestic
level of processing. Lastly, the importance of simultaneous

synthesis was stressed as a condition for complex intel-
lectual processes "whether the grammatical system of a
language or a system of arithmetical concepts [p. 76]."
"The grasping of any system of relationships . . . is
impossible without arrangement of the elements into a
simultaneously surveyable scheme [p. 76]." This is evi-
dent in the fact that a disturbance of the simultaneous
function can effect a "disintegration of . . . correspond-
ing grammatical relationships [Luria, p. 76]." On the
basis of observations of patients with brain lesions Luria
suggested that the parieto-occipital region of the cortex
is specialized for the synthesis of elements into spatial
groups.

Following his discussion of the levels of simul-
taneous synthesis, Luria described its perceptual counter-
part, successive synthesis. Such synthesis functions in a
dissimilar manner to the extent that stimuli are not
simultaneously surveyable, but are united into a series
such that each stimulus is a part of a serial order in
which they are interrelated as links of a chain. Luria
has proposed that the parieto-temporal region of the brain
is responsible for the synthesis just described.

Examples Luria used to demonstrate this operation
at the perceptual level are a melody, in which elements
are organized in time, and any skilled movement in which an
initial movement evokes the expression of a specific order
of other movements, forming a "kinetic melody [p. 78]."

With respect to language, which is a manifes-
tation of a sequential system at the intellectual level,
Luria cited narrative speech, confirming Lashley's
observations.

In accord with Luria's theory, Lashley delineated
language as an advanced form of integrative functioning,
when, in an essay entitled, "The Problem of Serial Order,"
(1960) he described the phenomenon as representing
". . . in a most striking form the integrative functions
that are characteristic of the cerebral cortex and that
reach their highest development in human thought pro-
cesses [p. 507]." He pointed out that temporal inte-
gration is not exclusive to language, but can be found in
all coordinated movements of humans, as well as those of
other animals. While temporally integrated actions occur
among even insects, "they do not reach any degree of
complexity until the appearance of the cerebral cortex
[p. 508]."

Considering the structure of the sentence, Lashley
suggested that numerous integrative processes can be
inferred to take place in the process of their construc-
tion. He thus proceeded to describe in detail the hier-
archy of integrations involved in the expression of
language. Lashley presented a detailed analysis of the
pronunciation of a word:

> Pronunciation of the word "right" consists first of
> the retraction and elevation of the tongue, expiration
> of air and activation of the vocal chords; second,

depression of the tongue and jaw; third, elevation
of the tongue to touch the dental ridge, stopping
of vocalization, and forceful expiration of air
with depression of the tongue and jaw . . . .
Pronunciation of the word "tire" involves the same
motor elements in reverse order. Such movements
occur in all permutations [p. 509].

Not only has Lashley presented a very graphic

account of the complexity of the enunciation of a word,

even more importantly, he alerts his readers to the fact

that the order of the motor elements is not due to an

intrinsic association between them, but is instead the

result of the control or direction of some discrete

agent. Lashley next advanced his proposal to account

for the syntax of sentences.

From such considerations it seems to follow that
syntax is not inherent in the words employed in
the idea to be expressed. It is a generalized
pattern imposed upon specific acts as they
occur [p. 511].

Lashley presented a convincing argument to demonstrate the

generality of the problem of syntax in the following

statement:

. . . the problems raised by the organization of
language seem to be characteristic of almost all
other cerebral activity. There are a series of
hierarchies of organization: the order of vocal
movements in pronouncing the words, the order of
words in the sentence, the order of sentences in
the paragraph, the rational order of paragraphs
in a discourse [p. 515]. (emphasis added)

By providing a comprehensive analysis of the sym-

bolic modes including visual imagery and language, Paivio,

in his book entitled Imagery and Verbal Processes (1971),

developed the theoretical discussion concerned with the

integration of stimuli. Paivio imparted a modality-specific viewpoint when he expressed that the verbal system is specialized for sequential processing dealing with temporally organized patterns, while visual perception can be regarded to be specialized for parallel processing of spatial stimuli. He spoke of Neisser, who suggested a principal of operationally parallel functioning in addition to parallel organization of stimuli. Operationally parallel functioning is not necessarily simultaneous, as parallel functioning is. Instead, if items can be serially ordered but any element in a system is not dependent on the outcome of another, they function independently. On the other hand, sequential processing is defined by the interdependency of the units in the sequence, i.e., one point in a sequence is determined by the point prior to it and in turn determines the next in the series. Visual imagery, according to Paivio, is a parallel processing system, both spatially and operationally, but it has a capacity for serial processing.

Paivio found parallel and sequential processing features in the verbal symbolic system as well. However, he qualified, because the verbal symbolic system is functionally associated with the auditory-motor system it is only operationally parallel. He claimed that due to "considerable freedom of choice or independence of the units at any level--one is free to say what one wants and

there are different ways of saying it; this process is operationally parallel [p. 36]." However, this argument seems a bit weak. Paivio's statement that meaning is determined by the orderly arrangement of units is more convincing.

There has been some research which has called into question the existence of the simultaneous and successive processes. These conditions may or may not occur in the processing of information as described by the above investigators, but it appears important to retain these constructs for the purpose of describing the nature of input and response (see Tulving & Lindsay, 1967; and references they make to Treisman & Broadbent and Gregory).

Physiological Attempts to Explain
Integrative Processes

Most of the research is in agreement regarding the obvious--that there is an integrative mechanism responsible for the synthesis and equivalence of different sensory modes. That experiences seem to be (1) equipotential and (2) intermodaly reciprocal, has led many investigators of this phenomenon to conceive of cross-modality as a function regulated by a discrete mechanism which operates independent of the efferent system. The questions, however, remain: What is it? Where is it? What color is it? How many is it? The pursuit for some physiological manifestations of this mechanism to provide observable evidence of its existence is not wholly

dissimilar to the evolutionists' search for the hypo-
thetically deduced missing link.

It is perhaps the case that process can be hypo-
thesized on the basis of an understanding of input and
response--the conceptualization to follow is an illus-
tration intended to explicate a relationship: that of
the input, process, response trilogy (see Figure 1).

This framework should elucidate some of the
structural ambiguities concerning the system of cross-
modal coding and simultaneous and successive processes.
Though the "process" could be the same mechanism respon-
sible for both cross-modal integration and the integrative
activity of simultaneous and successive integration, they
may on the other hand be different mechanisms. It would
be the case that the mechanism is the same for both pro-
cesses if stimuli were in fact modality-congruent. The
illustration, however, is intended to apply to both.

This is not an attempt to suggest that by such
an effort we can derive an explanation of the "process"
which will be empirically satisfactory. However, the
conjecture does suggest a viable direction of concentration
for further research, as well as a framework from which to
examine the research in retrospect. This is to say that
information describing the contingencies relating input
to response would enhance our efforts to understand the
conduct of the process. Possibly, once we are capable of

OUTPUT

RESPONSE

Examples:
--nature of task
--response

--something that can be measured and operationalized but explanations of a causal nature are often disputed
--may be delivered by means of any sensory modality
--may be emitted simultaneously or successively
--may involve a discrimination among choices

PROCESS

CODING

Examples:
--synthesis
--place of integration

--can be described physiologically but in general is still a missing link
--the relationship between input and output is the process which accounts for judgements of equivalence in both cross-modal processing and simultaneous and successive processing

INPUT

STIMULUS

Examples:
--nature of task
--stimuli
--presentation mode

--we can analyze this; it is a physical or behavioural manifestation
--here we can use successive and simultaneous labels for descriptive purposes
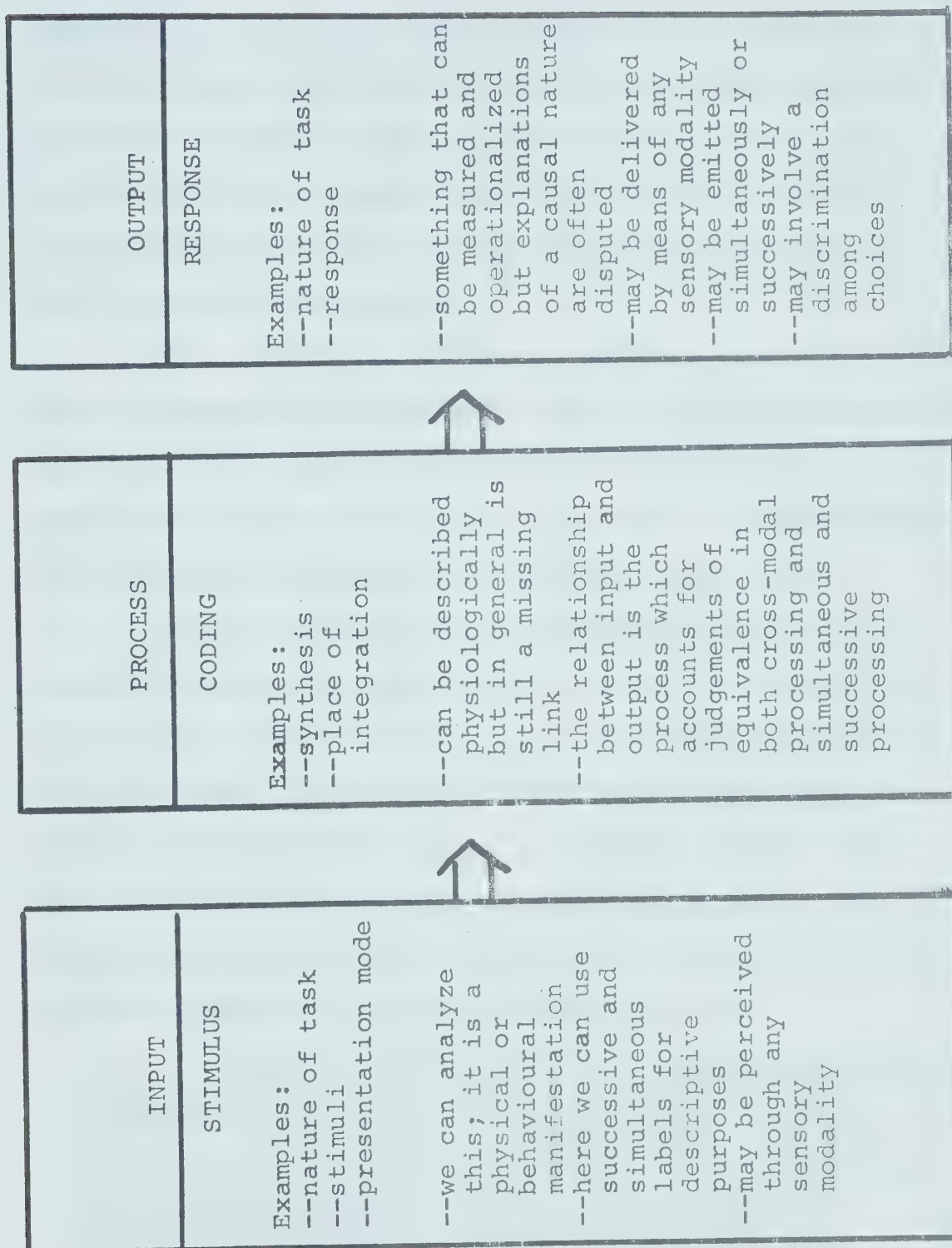--may be perceived through any sensory modality

Fig. 1.--Conceptualization of the relationship between stimulus, coding and response.

determining a physical representation of the features of
cerebral organization, we can use our knowledge about the
nature of a stimulus and response to account for the
equivalence among sensory modes and the way in which
transfer occurs, including the nature of simultaneous
and successive integration.

What follows is a summary of just such a search
for an integrative mechanism. Three persons in particular
have presented cogent descriptions of the physiological
activities hypothesized to be responsible for simultaneous
and successive processing and modality equivalence.

Attempts to explain the mechanisms involved in
cerebral integrative functioning seem to have begun with
Luria (1966) and his studies of brain-damaged patients.
Observing that disturbances in the visual and acoustic
spheres resulted from lesions in specific areas of the
brain led Luria to conclude that certain areas of the
cortex specialize in the synthesis of stimuli into simul-
taneous groups and successive series (p. 79):

> Whereas lesions situated within the parieto-occipital
> region of the cortex causes disturbances of the
> synthesis of elements into simultaneous (spatial)
> groups, investigations of patients with lesion of
> the anterior regions of the brain and primarily of
> the frontal-temporal regions, yield completely
> different results . . . . They are primarily
> associated with the analysis of stimuli separated
> from each other in time and with their synthesis
> into successive series [p. 103]. (emphasis added)

Luria's claim that integrative functions tend to
be modality congruent or (he might prefer) modality

specialized, is a deduction derived on the basis of observing impaired subjects, which for some seems to be an unsophisticated jump to conclusions. However, the association between particular sensory modes and certain integrative functions is not entirely unfounded, as other research has demonstrated.

K. S. Lashley (1960) submitted that there appears to be a mechanism responsible for parallel and sequential organization. Lashley concluded that nervous organization probably consists of "elaborate systems of interrelated neurons capable of imposing certain types of integration upon a large number of widely spaced effector elements [p. 520]." He hypothesized that successive and simultaneous systems are distinct in that successivity seems to be a manifestation of temporally distributed waves of effector excitations, while simultaneity occurs when receptor and effector elements are directionally polarized. Lashley referred to these processes as "a sort of substratum upon which other activity is built [p. 520]."

With regard to language, a recognized complex type of integration, Lashley posited that before words are used in a sentence they may be held in a state of partial excitation, or "primed," as he designated it, while another neural system scans the arrangement to determine the order in which the sentence will be emitted: "that elements of the sentence are readied or partially activated before the

order is imposed upon them in expression, suggests that some scanning mechanism must be at play in regulating their temporal sequence [p. 422]." Lashley's position rests in the hypothesis stage of sciencing, but represents a very credible viewpoint nonetheless.

Karl Pribram, in Languages of the Brain (1971), seemed to concur with Lashley. He discussed the work of Don Perkel and Theodore Bullock (1971, p. 74), who have studied simultaneous and successive coding in fish. Although Pribram had not been able to isolate analogous processes in the human brain, he suggested that it is highly possible that such coding operates in man as well. Essentially, Perkel and Bullock examined the radar-like signals discharged by the electric organs of the fish. There appeared to be evidence of temporal codes in the form of

> . . . shifts in latency, the duration of bursts,
> the overall probability of firing and the variation
> in this probability, the incrementing or decrementing
> of firing or its rate of change are all altered in
> one or another set of conditions [p. 74].

Perkel and Bullock referred to the spatial coding that they observed as "ensemble" processing. Arrays of parallel nerve fibers or spatially distributed "impulse trains" were observed to suggest this. As Pribram reported, Perkel and Bullock hypothesized that probably another mechanism in the Central Nervous System was responsible for integrating the messages. Pribram logically inferred that such a

mechanism would account for the integration of stimuli in the human brain. He believed this mechanism to "take place at neural junctions in the production of slow potential microstructures resulting from the interactions among ensembles of neighboring and successive impulse coded signals [p. 74]." It is evident that before psychologists will accept this account, Pribram's physiological explanatory "package" must be adopted in its entirity. Only further research can determine its validity.

Summary

Three noteworthy investigators, Luria, Lashley and Paivio, have commented on the phenomenon of language and its relation to certain perceptual processes. All three maintained that the conduct of language at various levels of complexity is dependent upon cortical information processing of a binary nature. These processes are simultaneous and successive integration of stimuli perceived through visual, auditory and tactual modalities.

Luria discussed the (1) temporal aspects of successive synthesis in which a serial order dominates the organization of discrete stimuli, and (2) an apparent spatial dimension of the integrating mechanism which permits stimuli to be surveyed concurrently. This dimension is proposed to account for the human ability to understand and generate grammatical units in the form of relationships.

Lashley elaborated on Luria's conceptual framework by describing the multi-organizational operations essential for the production of language. The integration of these operations is attributed to some supra-ordinate controlling mechanism.

Paivio tendered the notion that particular sensory modalities appear to be specialized in dealing with the two integrative functions just described. This notion bears a marked resemblance to Luria's suggestion that specific areas of the brain are specialized for simultaneous and successive processing.

The three investigators under discussion have contributed a great deal to our understanding of the nature of perceptual stimuli and their relationship in behavioral and linguistic contexts. But the first two, Luria and Lashley, and another, Pribram, have made attempts to determine the physiological process by which stimuli are cerebrally integrated.

Luria proposed that there appears to be some evidence for areas of the brain which are specialized for dealing with simultaneous or successive series of stimuli. These areas, not by chance, correspond to the loci of visual and auditory perception. Luria thus posited the locations in the brain where he believed integrative functions take place.

Lashley offered a description of integration which is even more specific than that of Luria. He arrived at an

explanation which suggests that there is a scanning mechanism made up of ". . . elaborate systems of inter-related neurons [1960, p. 520]," which would account for the ability to integrate stimuli. Pribram, on the other hand, submitted that human spatial and temporal processing operates much like that which Perkel and Bullock observed in fish, and regards processing to be the result of ". . . interactions among ensembles of . . . impulse coded signals [1971, p. 74]."

Each of these attempts to explain the physiological nature of the integrative mechanisms, or processes, are logically sound, but the actual process as yet remains empirically unidentified. It is reasonable to conclude then, that these attempts are, in fact, only hypothetical constructs. This thesis will therefore attempt to discuss the problem of integration in terms of what can be measured and identified, i.e., to discuss the conduct of input and response.

Comprehension Notwithstanding: The Reading Process

When we speak of reading in education today we are often inclined to elevate it to an almost mystical level of complexity. An attitude of this kind generally regards reading as a phenomenon inseparable from its associated linguistic components. However, reading can be analyzed as an independent phenomenon when we consider it in terms of process and not function. Reading is very simply a decoding

process. It is a process that requires transfer of written material from a visual to an auditory mode. When a child learns to read, he perceives words (visual input) and then says them aloud or to himself (decodes them into an auditory mode). Clearly, this process assumes that the mode into which the word is coded (the oral mode) is intact. Reading is thus considered to be auditorally based and the predominant method of teaching reading is an oral one. We refer to this process of transferring visually-perceived words to verbalizing them as The Look-Say Method or cross-modal transfer (transfer from a visual to an auditory mode or an auditory to a visual mode).

Stimuli distributed in a temporal fashion are judged to be more specific to processing by the auditory modality due to the nature of auditory perception, whereas stimuli distributed in a spatial fashion are more likely to be processed by the visual modality.

There is reason to believe that the deaf will be poorer than their hearing peers at solving cross-modal tasks involving transfer from a temporal to a spatial mode of processing and a spatial to a temporal mode. Hermelin and O'Connor (1971) have dealt with sensory deprivation studies demonstrating that (1) hearing subjects show a preference for coding information temporally, and (2) deaf subjects have a tendency to process information spatially.

It is hoped that an examination of the literature and the study following it will suggest an optimum method

of instruction for the deaf, whereby information will be processed efficiently and reading difficulties will be minimized.

The following representation shows that there can be an interaction across modes and between conditions. Each mode can be presented in either a simultaneous or successive condition. That is, a pattern of stimuli can be presented all at once in a spatial array or in discrete units temporally distributed. A schematic representation of the cross-modal transfer process appears in Figure 2.

A Correlate of Reading Achievement:

Cross-Modal Ability

Although the manner in which information is processed by the brain is important for our understanding of the perceptual aspects of deafness, our investigation is not complete until the nature of the reading process is more thoroughly understood.

In their 1964 studies, Birch and Belmont attempted to relate cross-modal transfer (CMT) success to the ability of learning to read. Referring to a study by Harris (1964, p. 858), Birch and Belmont pointed out that reading involves learning to recognize visual counterparts of auditory symbols. This basis begins the framework of their hypothesis: "A primary disturbance in the ability to integrate stimuli from the two critical sense modalities, hearing and vision, may well serve to increase the risk of

Independent Variables

    Modes: auditory
                        visual
                        tactile

    Conditions: simultaneous
                        successive

Dependent Variable

    task results

        X = Cross-modal transfer

        O = No cross-modal transfer

	P R E S E N T A T I O N M O D E		
	AUDITORY	VISUAL	TACTUAL
AUDITORY	O	X	X
VISUAL	X	O	X
TACTUAL	X	X	O

(Row labels under RESPONSE MODE)

Fig. 2.--A schematic representation of the
cross-modal transfer process.

becoming a poor reader [1964, p. 858]." In an experi-
mental setting, subjects were required to identify a
visual-spatial dot pattern following presentation of a
corresponding auditory-temporal sequence and vice versa.
This task implicitly involved a recognition of the equi-
valence of these modalities and a transfer of learning.
Results of 150 retarded and 50 normal readers were then
compared to reading achievement. As predicted, poor
readers were less able to integrate stimuli across moda-
lities than good readers, although reading incompetence
is not entirely attributed to cross-modal transfer.
Evidence cited to support the proposition is the same as
that used to substantiate mediational theories, i.e.,
CMT is not an ability characteristic of young children and
animals (Gibson, 1969, p. 220). Although CMT has been
observed to occur later in development, for the most part
(such as the failure of 3-year olds to perform CMT tasks,
but success for 5-year olds) the assumption that develop-
ment alone is responsible is not convincing.

It may be that the ability to perform such tasks
does not become manifest until experience in the perfor-
mance of these activities has been established. O'Connor
and Hermelin (1964) suggested that experience with
modality-specific processing and coding is effective in
eliciting transfer abilities. "Tactile presentation may
have to be more frequent for the formation of a stable

image which could be transferred to another modality
[p. 234]." Further evidence is indicated by the obser-
vation that transfer from successive auditory stimuli was
found to be less difficult for young hearing subjects
(Furth, 1966, p. 447). Furth stated that linguistic
experience provides practice in "discriminating and
learning combinations of sequentially presented material
[p. 447]." He advanced that an experiential deficit in
sequential tasks is cause for the inferior scores of the
hearing-impaired subjects on successive tasks.

An experiment reported by Carterette and Jones
(1967) supports Furth's conclusion. Carterette and Jones
described their experiment as part of a series which
examined the influence of linguistic redundancy on the
ability to learn verbal material. This experiment, in
particular, sought to investigate the precision with which
subjects respond to auditorally and visually presented
verbal material. Three groups of children at different
age levels were compared with adults on tasks requiring
continuous processing of sequentially presented infor-
mation. This procedure was chosen on the basis of its
resemblance to the reading and listening process. Subjects
were merely required to respond by saying "old" or "new"
to the presentations. Experimenters concluded that modal-
ity of presentation was a significant factor in language
processing leading them to suggest that visual and

auditory presentations are not equally as effective for the presentation of verbal information at all ages. Despite the fact that words of high language frequency were presented, younger children performed more poorly than older ones and adults for visually presented lists. Accuracy for visually presented material increased with age until adulthood when processing of visual material was equal to that of auditory. The experimenters inferred that differences were probably due to experience. The school, in which students are required to attend to visually presented information, provides such experience.

Summary

It has been suggested that the ability to integrate stimuli from the visual to auditory or auditory to visual modalities is necessary for becoming an adequate reader (Birch & Belmont, 1964). Several investigators (Carterette & Jones, 1967; Furth, 1966; O'Connor & Hermelin, 1964) have concluded, on the basis of empirical findings, that experience with cross-modal coding is responsible for the differences found between those who perform well and those who perform more poorly on tasks involving judgements of equivalence between modes, i.e., reading tasks.

After Information is Stored: The Process

of Cross-Modal Transfer

The general procedure for cross-modal transfer
experiments involves (1) training a subject in one modality
to make responses to a set of stimuli and (2) following
training, to make similar responses to stimuli that are
equivalent or resemble that of the training task, but
(3) are presented in a different modality. Transfer is
considered to have taken place if the subject was able
to identify corresponding stimuli in another modality.
It is assumed that recognition of a stimulus presented in
another modality is facilitated by the training procedure.
Cross-modal research has included transfer from tactile,
visual and auditory modalities involving all permutations
of these in combination. Whether or not verbal mediation
is necessary for translating one type of modality input
into another has been debated.

Cross-Modal Transfer: The Mediation Hypothesis

Versus The Developmental and

Learning Viewpoint

A. The mediation hypothesis. The mediation hypo-
thesis implies that CMT is a characteristic of the
verbally-inclined: those who are familiar enough with the
manipulation of language symbols to describe the invariant
features of modality inputs and transfer them to equivalent
stimuli in another modality.

In an experiment in which transfer effects from touch to vision and vision to touch were measured, Gaydos (1969) concluded that "verbalization seemed to play an important part in the learning for many of the subjects [p. 109]." The experimenter postulated that verbal associations established in training could facilitate subjects' performance on subsequent discrimination tasks. During the initial sessions, subjects in the experiment were trained to pair the names of males with specific shapes. Those subjects who discriminated shapes across modes at the fastest rate (i.e., the fastest learners) did, in fact, resort to the verbal associations they acquired during training (p. 109).

Other mediational theories are founded on the evidence that younger children (pre-verbal) and animals (non-verbal) often fail problems requiring cross-modal transfer. Such studies have been cited by Gibson (1969) and Hermelin and O'Connor (1964, p. 229). The most often noted studies performed with monkeys have been those of the early 1960's. Ettlinger (1960) and Wilson (1963) reported weak and negative results in experiments which required monkeys to transfer cross-modally from a visual discrimination to a tactual one or tactual to a visual discrimination task. Hermelin and O'Connor (1964) inform us of some findings that would seem compatible:

Wilson and Wilson found that monkeys with lesions in the parietopreoccipital area showed no facilitation

in visual learning tasks from prior tactual
experience. On the other hand, O'Connor and
Hermelin demonstrated that some cross-modal recog-
nition between visual and verbal material . . .
occured in severely subnormal subjects [1964, p. 229].

Blank and Bridger, in another experiment (1964),
aimed towards discovering the importance of verbal media-
tion, and postulated that there are in fact two kinds of
cross-modal transfer (CMT). In one experiment the
children held objects that were not equivalent, but
characterized properties similar to those objects they
perceived visually: stimuli were dissimilar but analogous.
This problem Blank and Bridger termed cross-modal concept
(CMC). In the other experiment they observed the children's
ability to discriminate which of two objects they perceived
visually, was identical, or "equivalent" to an object they
perceived haptically (cross-modal equivalence or CME).
The former was assumed to require mediation because trans-
fer was to an analogous but not equivalent stimulus. On
the other hand, cross-modal equivalent problems were con-
sidered to involve corresponding stimuli in another
modality. Blank and Bridger hypothesized that CMC would
be language dependent and CME would not. Although the
results supported their predictions, it was found that
verbalization alone is insufficient for CMC transfer:
"Several children labelled the stimuli one and two and
still failed to solve the problems [1964, p. 287]."
Language was, therefore, a necessary but not sufficient
function of solving CMC problems.

To counter these findings, Gibson also pointed out that other studies have obtained dissimilar results. Studies conducted by O'Connor and Hermelin (1964, 1965, 1971) and Furth (1964, 1966, 1967) on the deaf have supported this attitude. In tests to discover the dependence of cross-modal transfer on words, O'Connor and Hermelin found no difference in groups with different verbal ability. "Thus words probably play no decisive part in this type of transfer between sensory systems [1964, p. 233]."

Having determined that language plays only a minor part in cross-sensory transfer tasks, we are led to consider another viewpoint to account for the phenomenon.

B. The developmental and learning viewpoint. This viewpoint proposes that the ability to integrate stimuli across modalities is a function of learning (Gibson, 1969). Emphasis is given to the unity of the senses. This approach states that sensory modalities begin as distinct and specific abilities from birth. At this time CMT would not be possible, but during development these functions are integrated. To the extent that learning takes place in the presence of development we may consider CMT as a "perceptual development" that takes place through learning. Discovering transformational features could be viewed as a result of learning experiences.

Gibson has discussed Piaget's developmental viewpoint:

> . . . progressive development of exploratory handling with increasing search for significant features. The sensory-motor schema is a kind of referrent common to two modalities, making cross-modal transfer possible [Gibson, 1969, p. 230].

Gibson has remarked, appropriately, that this concept is a difficult one to test.

Two experimenters, Gibson also noted, support a developmental viewpoint. Birch and Lefford (1963) presented as evidence developmental curves for intermodal matching which indicated that correct matching increases with age. Her own analysis of the process introduced the notion of amodal invariants in stimulation. These amodal invariants Gibson defined as higher order properties of stimulus information which are not sensation specific. Intensity, extent and temporal and spatial patterns are examples (1969, pp. 220-221). These examples are not unlike those conditions, simultaneous and successive, that are considered to be modality-congruent by other investigators (Hirsh, Bilger & Deathridge, 1956; Birch & Belmont, 1964; O'Connor & Hermelin, 1971). Gibson did not deny that features of stimuli can be modality-congruent, but she preferred to concentrate on modality features that are common to several different modalities. She termed this relational. Gibson's examples seem to indicate that she has redefined modality-congruency.

In the O'Connor and Hermelin study (1971), subjects deprived of experience in specific sensory modalities were unable to perform tasks that demanded their attention to stimuli in the non-functioning modality. Although visual-temporal choices were available, deaf subjects tended to ignore them because of their restriction to the visual modality and hence visual spatial coding. The deaf and blind subjects in this experiment constituted good control groups to demonstrate the learning and experiential facet of cross-modal transfer.

Process as a Function of Presentation: Are Stimuli Modality-Congruent?

While there seems to be no hard and fast associations between the nature of stimulus presentation and sensory modality, most of the research lends support to the view that spatially distributed stimuli are best apprehended through vision while temporally distributed stimuli are more easily perceived through audition. For those persons whose sensory receptors are intact, stimuli are perceived in either a spatial or temporal fashion.

One of the earliest studies to suggest a relationship between patterns generated over time and their dependence on auditory perception was performed by Hirsh, Bilger and Deathridge (1956). The duration of tone and light stimuli was considered within auditory and visual contexts respectively.

Subjects were presented with two stimuli: an
auditory stimulus (a tone) and a visual stimulus (a light)
against a background of auditory noise (90 db) in the
first condition and against a background of quiet as the
second condition. Afterwards, subjects were asked to
report the durations of the stimuli. Responses of the
subjects indicated that when the duration of a tone or
light was held constant during each condition, subjects'
perception of their duration differed markedly relative to
the level of background auditory stimulation. Hirsh,
Bilger and Deathridge concluded that "perceived time
varies with the level of auditory stimulation [p. 562]."
In a second part of the experiment, auditory and visual
stimuli were presented against a background of visual
ambient stimuli (brightness) and darkness. When the
subjects were required to reproduce the duration of these
stimuli, there appeared to be no difference in perception
of durations when tone or light had been presented against
a background of varying levels of brightness.

The experimenters summarized these results
conclusively in the following statement.

> . . . in this study only acoustic and not visual,
> ambient stimulation seems capable of eliciting marked
> changes in the rate at which the psychological clock
> operates [p. 572].

The results indicate that perceived duration of a
tone or light is significantly dependent on the level of
auditory stimulation, but these stimuli are little affected
by visual ambient stimulation.

Later, the notion that the extent of cross-modal transfer is subject to variations of conditions (simultaneous and successive presentations) was advanced by Krauthamer (1959). In this experiment, subjects were presented with a series of patterns under two conditions. In the first, patterns were traced with a stylus of pinpointed light (successively) and in the second, drawings of metal dies were presented (simultaneously). Transfer occurred across vision and touch modalities. Although Krauthamer's study did not describe the precise nature of the dependence of modality transfer on conditions of presentation, the results of the study lean in the direction of a modality-congruent viewpoint, such that "the extent of transfer depended on conditions of the stimulus [1959, p. 396]."

Developing this concept even further, Birch and Belmont (1964) explored the relationship between a temporally structured set of auditory stimuli and a spatially distributed set of visual ones. Apart from the fact that they were trying to determine the correlation between reading retardation and success at cross-modal coding tasks, Birch and Belmont built into their experiment a modality-congruent feature, i.e., a visual dot pattern was spatially distributed and corresponded to a rhythmic auditory pattern, temporally distributed. The assumption implicit in this presentation was that auditory-temporal

stimuli can be made equivalent to visual-spatial stimuli.
Because reasons for pairing of these modes and conditions
were not provided by the experimenters, we can only assume
that Birch and Belmont recognized their modality-congruent
attributes.

The hypothesis Birch and Belmont (1964) set out to
test was supported by their findings. These findings
indicated that retarded readers differ significantly from
normal readers on the experimental tasks. The results
suggested therefore, that retarded readers of normal intel-
ligence are less proficient judges of auditory-visual
equivalence.

In another auditory-visual sequencing experiment,
there was no pairing into auditory-temporal and visual-
spatial arrangements as in the Birch study. Furth (1966)
conducted an experiment in which visual material was pre-
sented both simultaneously (spatially) and successively
(temporally) and auditory stimuli were successively
(temporally) presented. Deaf and hearing subjects were
compared in their performance on these tasks. Deaf sub-
jects demonstrated greater success with simultaneous than
with successive sequences. The hearing subjects did better
than the deaf on successively presented material, regard-
less of the modality. Furth attributed the difference
between groups to experiential factors. The results of
this later experiment (Furth, 1966) differed from an

earlier one in which fewer differences were found between successive and simultaneous sequence learning; "mean sequence errors between the aphasic and deaf group yielded to well below acceptable criteria of significance [Furth, 1964a, p. 176]." These negligible differences indicated to Furth that any difficulties were due to the combinative aspect of sequences. He suggested that, ". . . there may not be too much difference between these modes of presentation [p. 352]." Furth's interpretation is contrary to a more recent experiment of O'Connor and Hermelin (1971) which will be discussed in the latter part of this section.

Work being done in the Soviet Union by Luria (1966) appears to differ with Furth's interpretation of the relationship between auditory and visual sequences. Luria has developed the concept of visual, motor, tactile and acoustic analyzers that organize stimuli into simultaneous and successive groupings:

> It is well known that the tactile and also to a large extent the visual analyzer receives a successive series of stimuli but integrates this series into simultaneous groups. . . . However, the main form of operation of these (motoric and acoustic) analyzers is the conversion of this original scheme into an expanded serially organized successive group [1966, p. 125-126]. (emphasis added)

While approaching a semblance of the O'Connor and Hermelin paradigm (to be discussed later) of modality-congruent attributes, Luria's explanation of the processes involved in perception diverges nonetheless. He proposed

that stimuli presented successively through the visual channel will be reorganized into simultaneous groups in processing and coding and that the converse will be true for the auditory mode. This suggests that the nature of the stimulus input will be altered into the modality-congruent condition when it is received by an analyzer. O'Connor and Hermelin later demonstrate that stimuli presented in a successive or temporal condition will be ignored if the modality of input is visual.

Roman Jakobson (1967) whose interest in the sequential character of speech has led him to investigate the relation between visual and auditory signs, concurred with Krauthamer (1959) and Birch and Belmont's (1964) viewpoint concerning modal attributes. Jakobson has told us that, "In visual signs it is the spatial dimension which takes priority, whereas the temporal dimension takes priority in auditory signs. Auditory signs act in a time sequence [p. 3]."

An experiment giving support to Jakobson's notion that the temporal dimension assumes priority in auditory signs was performed by Harris Savin (1967). Subjects were presented with simultaneous auditory stimuli (a different message to each ear occurring at the same time). Rather than combining the perceptions of each ear, subjects reported messages heard by each ear successively. These results demonstrated that subjects could not group

simultaneously presented messages simultaneously when the input was auditory. Similarly, Luria submitted that simultaneous information will be converted to a successive condition by means of an "analyzer." Savin suggested that auditory stimuli can only be perceived successively.

Tulving and Lindsay brought into question the sequential processing hypothesis that has been invoked to explain the ability of subjects to respond to simultaneously presented auditory stimuli. They attempted to demonstrate the non-existence of a "temporary pre-perceptual store" in which information from one channel is said to be held in store prior to processing. This pre-perceptual store, as postulated by Broadbent allows attention to be directed to another channel.

By estimating the shortest period of time in which information can be processed but controlling the duration to obviate attention switching, Tulving and Lindsay attempted to demonstrate that stimuli would be identified as accurately as would be the case for a longer duration of input.

If, as expected, inputs from two different modalities could be processed as accurately when presented for a short duration as when presented for a longer one, the results would support the notion that stimuli were not successively attended to, but that some other process was responsible for the ability of subjects to identify both

stimuli. They suggested that duration would be the critical variable in a test of the sequential hypothesis.

Stimuli were of two varieties: (1) visual stimuli consisted of circular patches of white light and (2) auditory stimuli were pure tones. Stimuli were varied along the dimensions of intensity and duration. Four different tasks were presented; two of which presented two stimuli simultaneously from both modalities, and subjects were required to make judgements and attend to both. The amount of transmitted information per modality was the main response variable.

Results failed to find a significant interaction between duration and intensity, indicating relatively no difference between response accuracy in the short and long duration conditions. The tenability of the sequential processing hypothesis was doubtful.

Tulving and Lindsay concluded that explanations for the data appeared to be more compatible with some views of the attention mechanism than with the sequential hypothesis. These findings should be considered with respect to the experiment by Savin, just described, in that the conclusions of Tulving and Lindsay imply that simultaneous processing of auditory input may indeed be possible given the appropriate circumstances.

Bennet Murdock (1969) set out to demonstrate that studies indicating the superiority of short term memory

when stimuli are presented in an auditory mode were not
entirely valid as evidenced by the fact that the auditory
mode is simply more compatible with temporal distributions
(p. 378). Murdock experimentally attempted to provide
both a spatial and a temporal distribution which could be
used in either an auditory or visual presentation. To
accomplish this he constructed an apparatus in which eight
loudspeakers were arranged in a clockwise display and had
eight slide projectors focused on them. "Each item thus
had a unique temporal and spatial position [p. 379]."
Words were sequentially projected on the eight speakers
and subjects were required to find the spatial position
of temporally presented stimuli. The results of Murdock's
experiment did not support his hypothesis; i.e., he
determined that temporal associations are not required in
STM experiments. Correct responses could be determined by
spatial position although he found fewer errors for the
auditory than the visual presentation. Murdock's attempts
to effect a separation between auditory-temporal and
visual-spatial distributions precede an even more impres-
sive design carried out by O'Connor and Hermelin (1971)
attempting to demonstrate modality associations.

Along these lines, O'Connor and Hermelin (1971)
have summarized a good deal of research concerned with the
view that visual and auditory input are related to temporal
and spatial perception. Their own experiments have

explored this concept further and demonstrated that among persons whose sensory experiences are limited to one distal receptor, stimuli will be organized according to the remaining modality of input. Their results indicated that in ambiguous situations, stimuli will be organized spatially or temporally depending on the nature of the input (auditory or visual); i.e., hearing and seeing children would respond in a like manner to their deaf and blind peers. One group of blind, one group of deaf and four groups of normal children, two of which were artificially restricted visually or auditorally, took part in the experiment. Subjects seeing (or hearing) a visual (or auditory) display of digits presented spatially and temporally, were instructed to choose the "middle" one. Spatial choices always coincided with temporal choices, so that the subject was forced to choose between them. Results consistently showed that in those cases where information was presented visually, subjects always chose the spatial unit and accordingly, when the stimulus was auditory, subjects made a temporal choice. For example, if the digits 8, 5 and 3 were successively displayed, 5 might be exposed first, then 3 and then 8. The temporal middle would be 3; the spatial middle would be 5. Deaf subjects would have chosen the spatial middle, 5.

The investigations conducted by O'Connor and Hermelin and their predecessors offer provocative evidence

concerning the modality-congruent operations of the deaf. If the deaf are restricted to one modality of input, specifically the visual, and therefore primarily process only spatially presented information, then suggestions can be made that perhaps (a) current attempts in the field of deaf education to teach the congenitally deaf to process auditory temporal stimuli when they are unable to perceive such a sequential arrangement are doomed to be unsuccessful; and (b) those who are successful in their speech training sessions have somehow managed to rely on attendant spatial cues to process for meaning.

The instructional implications are obvious. If temporal stimuli are being presented to the deaf, but only spatial coding is being processed, then instructional modification should involve an emphasis on the visual-spatial distribution of materials.

General Summary

The results of a study testing the mediation hypothesis (Gibson, 1969) suggest that language appears to be a necessary but not sufficient mediator in cross-modal transfer tasks. O'Connor and Hermelin (1964, 1965, 1971) and Furth (1964, 1966, 1967) determined that language was not at all necessary for the performance of cross-modal transfer. A few investigators (O'Connor & Hermelin, 1964, 1965, 1971; Furth, 1964, 1966, 1967) have ascertained that

the ability to integrate stimuli across modalities seems to be a function of learning and experience.

Most of the studies to date (O'Connor & Hermelin, 1971; Murdock, 1960; Savin, 1967; Jakobson, 1967; Krauthemer, 1959; Hirsh et al., 1956; Birch & Belmont, 1964) have concluded: (a) that stimuli tend to be modality-congruent, that is, simultaneous spatially distributed stimuli are best perceived through the visual modality, and successive spatially distributed stimuli are more easily apprehended through the auditory modality; and (b) that auditory-temporal stimuli could be made equiv-alent to visual-spatial stimuli.

Studies such as Furth's (1966), conducted with deaf subjects, presented visual-simultaneous, visual-successive, and auditory-successive stimuli and found that deaf subjects performed better on visual-simultaneous than on visual-successive and auditory-successive stimuli. These results were perhaps due to the modality-congruent attributes of the stimuli as well as the experiential factors. Luria (1966) proposed that all visual stimuli would be organized into simultaneous groups during pro-cessing, regardless of the condition of input (simultaneous or successive); the opposite would be true for the auditory modality.

These studies all seem to imply that modality-congruent attributes of stimuli are indeed important.

The implication would suggest that differences between deaf and hearing groups would be especially evident in responses which required transfer involving stimuli that are or are not modality-specific. From the earlier discussion of experience, it seems that persons lacking in experience with a particular modality would do more poorly on tasks requiring cross-modal transfer than those who have acquired experience. Noting these two possibilities, we might generate a third: due to modality-congruent attributes, persons who lack experience with a modality will also lack experience with a condition. Thus, deaf children lacking experience with the auditory modality will necessarily be deficient in making decisions of equivalence with regard to transfer to or from successive stimuli.

CHAPTER III

DEFINITIONS AND HYPOTHESES

Definitions

General Terms

Stimulus. In A Glossary of Behavioral Termi-
nology, White (1971) defines "stimulus" as follows.

> All objects . . . and events . . . in our envi-
> ronment are considered to be stimuli due to the
> fact that we are aware of them only inasmuch as
> they "stimulate" our senses (i.e. we must hear,
> see, touch or smell them before we know them to
> exist). Generally speaking we refer to an object
> or event as a stimulus if it occurs prior to or
> simultaneously with the response. [p. 165].

Thus the operational definition of "stimulus" in this

thesis is "inputs from different sensory channels."

Transfer. White (1971) defines this term with

the following statement. "Where the cues or relevant

stimulus dimensions . . . for problem solution in one

instance remain constant in another instance [p. 184]."

Cross-modal transfer. ". . . involves the

transfer of a principle . . . . Essentially a discrim-

imination based on a dimension or cue in one sensory

modality is transferred to a different sensory modality

using the same dimension or cue but in relation to
a different discriminada [O'Connor & Hermelin, undated,
p. 2]."

Intra-modal transfer. A discrimination based
on a dimension or cue in modality is transferred to the
same modality using the same dimension or cue.

Inspection stimulus. A stimulus having charac-
teristic dimensions which the subject is required to
retain and use as a basis for making decisions of
equivalence in the same or different modalities.

Response choices. Multiple choice stimuli
exposed, following the inspection stimulus, from which
the subject must make decisions regarding equivalence;
these may be presented in same or different modalities
than the inspection stimulus.

Simultaneous processing. Information presented
to the subject is organized into a spatial array by an
unidentified cerebral mechanism at points of neural
integration.

Successive processing. Information presented
to the subject is sequentially organized by some
unidentified cerebral mechanism at points of neural
integration.

Sensory integration. The unidentified process of synthesis which makes a transfer across sensory modes possible. Assumes equivalence between modes.

Modality congruence. A term describing the relationship of modalities to stimulus distributions. A current viewpoint suggests that the visual modality is specialized for spatial distributions of stimuli and the auditory and tactile modalities are congruent with temporal distributions of stimuli.

Independent Variables.

Simultaneous condition. Stimuli are presented concurrently in a spatial array. Parallel stimuli are simultaneously surveyable (coding dimension of space).

Successive condition. Stimuli are presented in discrete temporal units. Sequential stimuli are part of a serial order and can only be inspected for the duration of the exposure of each unit.

Sensory modalities. Touch, vision, audition, taste and smell. Only the first three will be dealt with in this thesis.

Visual-simultaneous. A pattern of stimuli presented in a spatial array (concurrently in time), to be perceived by the visual receptors.

Visual-successive. A pattern of stimuli presented in a temporal arrangement (discretely in time), to be perceived by the visual receptors.

Tactual-simultaneous. A pattern of stimuli presented in a spatial array (concurrently in time), to be perceived by the tactual receptors.

Tactual-successive. A pattern of stimuli presented in a temporal arrangement (discretely in time) to be perceived by the tactual receptors.

Auditory-successive. A pattern of stimuli presented in a temporal arrangement (discretely in time), to be perceived by the auditory receptors.

Hypotheses

Rationale 1. There are, in the literature, some
significant studies which propose that success on tasks
requiring the processing of simultaneous and successive
stimuli is probably related to the frequency with which
individuals are exposed to these sorts of sensory infor-
mation.

The basis for this notion derives from results
indicating that the deaf, a population of subjects that
are restricted in one modality of input, tend to perform
less well than their hearing counterparts on tasks
involving sequential presentations of stimuli. Furth
(1966) suggests the possibility that linguistic practice
provides the experience which would explain the superiority
of hearing subjects on such tasks. In Furth's 1966 study
comparing aphasic, deaf and hearing subjects on visual-
simultaneous, visual-successive and auditory-successive
tasks, he found that the younger deaf subjects performed
more poorly than the normal control group on the successive
sequence tasks but that these same children performed as
well on the simultaneous presentation of sequences. He
noted that, "In this study, contrary to the former one,
simultaneous presentation was generally somewhat easier
than successive presentation [p. 449]." This study also
revealed that older subjects (10- and 11-year olds)
performed as adequately as their hearing peers on the

successive tasks. Intensive training in linguistic skills
was believed to account for the improvement of the older
subjects and the evidence that the younger hearing child-
ren ". . . found auditory sequence easier than visual
sequence . . . [p. 448]." The lesson of the study is
perhaps most clearly revealed in the following statement:
". . . the poorer performance on sequential tasks can be
attributed to early deafness or linguistic deficiency in
general . . . [p. 447]."

Hermelin and O'Connor (1964) furnish similar proof
regarding the experiential factor in the processing of
information. They discuss the necessity for more frequent
tactile presentations in order to form stable images of
the stimuli which would thus facilitate transfer from
that modality to another.

We are again reminded of the experiential factor
concerning the processing of information when we refer to
Paivio's (1971) observation that the verbal system is
specialized for the processing of temporal stimuli while
visual perception is specialized for parallel processing
of spatial stimuli.

Hypothesis 1. The evidence provided by Furth,
Hermelin and O'Connor and Paivio suggest that the majority
of the pre-lingually deafened population, who by their
sensory deficit are less frequently exposed to the temporal
stimuli provided by the verbal system, will do less well

on tasks requiring the processing of temporally distrib-
uted stimuli than hearing control subjects. One might
expect that they would produce more correct responses
on tasks requiring transfers from and to visual-successive
stimuli than those requiring transfers from and to tactual-
successive and auditory-successive stimuli since the
visual modality is a more familiar one.

    1.1. Hearing subjects will produce more total
correct responses than deaf subjects on all successive
tasks.

    1.2. Deaf subjects will produce more total correct
responses on transfers to successive response choices in
the visual mode than in the tactual and auditory modalities.

    1.3. The data should indicate a learning trend
for deaf subjects on all transfer tasks due to the subjects'
ability to improve on these tasks as a result of experience
with the task.

    Rationale 2. The viewpoint which states that
spatial and temporal distribution of stimuli tend to be
specialized for, or more easily apprehended through certain
sensory modalities, suggests that the relationship between
sensory modalities and distributions is worth examination.
If it is assumed that O'Connor and Hermelin (1971) are
correct when they say that subjects "switch in" to the
coding distribution congruent with a particular modality
of presentation (e.g., visual-spatial/simultaneous), then

we might also suspect that subjects will have more diffi-
culty transferring to another distribution of stimuli that
is not congruent with that modality (e.g., visual-
temporal/successive) especially when that dimension is
one in which they lack experience (e.g., deaf lack
experience in successive processing). We might also
expect that since the visual modality is the primary
modality of input for the deaf (see Rationale for Hypo-
thesis l.) that the preferred mode and distribution for
processing are the visual and spatial/simultaneous ones,
or that they ". . . would dominate sensory organization
in a precipient [Hermelin & O'Connor, 1971, p. 6]."
We could anticipate that deaf subjects would perform best
on the transfer which involves their preferred modality
coupled with the stimulus distribution specific to it.

Hypothesis 2. Both deaf and hearing subjects will
produce more total correct responses on tasks involving
transfers to and from modality-congruent stimulus distrib-
utions than modality-incongruent stimulus distributions;
subjects who have experience with a condition of a
modality-incongruent stimulus distribution will produce
more correct responses than subjects lacking such
experience.

2.1. Both deaf and hearing subjects will produce
more total correct responses on transfers from visual-
simultaneous to visual-simultaneous than from

visual-simultaneous to visual-successive distributions.

2.2. Both deaf and hearing subjects will produce more total correct responses on transfers from visual-simultaneous to tactual-successive than from visual-simultaneous to tactual-simultaneous distributions.

2.3. Both deaf and hearing subjects will produce more total correct responses on transfers from tactual-successive to tactual-successive than from tactual-successive to tactual-simultaneous distributions.

2.4. Both deaf and hearing subjects will produce more total correct responses on transfers from tactual-successive to visual-simultaneous than from tactual-successive to visual-successive distributions.

2.5. Both deaf and hearing subjects will produce more total correct responses on transfers from tactual-successive to auditory-successive than from tactual-successive to tactual-simultaneous distributions.

2.6. Both deaf and hearing subjects will produce more total correct responses on transfers from visual-successive to visual-simultaneous than from visual-successive to tactual-simultaneous distributions.

2.7. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-simultaneous to auditory-successive distributions.

2.8. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-simultaneous to tactual-successive distributions.

2.9. Hearing subjects will produce more total correct responses than deaf subjects on transfers from tactual-successive to visual-successive distributions.

2.10. Hearing subjects will produce more total correct responses than deaf subjects on transfers from tactual-successive to auditory-successive distributions.

2.11. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-successive to visual-successive distributions.

2.12. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-successive to auditory-successive distributions.

2.13. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-successive to tactual-successive distributions.

Rationale 3. It seems to be the case that animals, young hearing subjects, young deaf subjects and retarded readers all have greater difficulty than normal children in integrating stimuli from two or three different modalities; that is, cross-modal transfer (cf. review of the literature). This study attempts to determine where the difficulties lie; from and to which modalities are the difficulties most predominant for the deaf? On the basis of the experiential hypothesis referred to in the earlier rationale, requiring subjects to transfer from one modality to another, the hypothesis below is proposed.

Hypothesis 3. On tasks requiring subjects to perceive stimuli in one modality and to recognize the equivalent stimuli in a different modality, hearing subjects will produce more correct responses than deaf subjects.

3.1. Hearing subjects will produce more correct responses than deaf subjects on transfers from visual-simultaneous to auditory-successive distributions.

3.2. Hearing subjects will produce more correct responses than deaf subjects on transfers from visual-simultaneous to tactual-simultaneous distributions.

3.3. Hearing subjects will produce more correct responses than deaf subjects on transfers from visual-simultaneous to tactual-successive distributions.

3.4. Hearing subjects will produce more correct responses than deaf subjects on transfers from visual-successive to auditory-successive distributions.

3.5. Hearing subjects will produce more correct responses than deaf subjects on transfers from visual-successive to tactual-simultaneous distributions.

3.6. Hearing subjects will produce more correct responses than deaf subjects on transfers from visual-successive to tactual-successive distributions.

3.7. Hearing subjects will produce more correct responses than deaf subjects on transfers from tactual-successive to visual-simultaneous distributions.

3.8. Hearing subjects will produce more correct responses than deaf subjects on transfers from tactual-successive to visual-successive distributions.

3.9. Hearing subjects will produce more correct responses than deaf subjects on transfers from tactual-successive to auditory-successive distributions.

CHAPTER IV

METHOD

Sample

The sample consisted of 72 children from three
different schools in the Edmonton area. Deaf and hearing
children comprised the two populations of comparison.
Ages of children ranged between eight and eighteen years;
a relatively broad age range resulted due to the limita-
tions presented by the availability of deaf subjects for
testing and ability of these subjects to comprehend
instructions.

Thirty-six deaf subjects were drawn from the
Alberta School for the Deaf. Students were chosen on the
basis of a severe to profound degree of hearing loss
(60 db. loss +) and onset of deafness (pre-lingually
and/or congenitally deafened). An additional criterion
of selection was the ability to retain at least three
units of information presented visually. Retention was
determined by responses to a modified version of the
Hiskey-Nebraska Memory Test for Colors for younger subjects;
a modified version of the Hiskey-Nebraska Test for Numbers
was used for older subjects. Based on results obtained with
this screening device, subjects below the age of eight were

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not included in the sample. Subjects selected for testing were then randomly assigned to one of three groups and tested in a random order determined by their availability to researchers. Subjects included both residential and day students and represented all socioeconomic levels. The testing of all deaf subjects was conducted at the Alberta School for the Deaf.

Thirty-six hearing subjects were randomly selected from two Edmonton public schools chosen on the basis of their proximity to the University where the testing took place. The only criteria determining the participation of these subjects were age and the consideration that they were of normal abilities. As nearly as possible, hearing subjects were matched in age to the deaf subjects.

Deaf subjects were randomly assigned to one of three different groups described by the nature of the stimulus presentation. Hearing subjects were assigned to the same groups as their age-mate counterparts.

Deaf children ranged in age from 8 years, 6 months, to 18 years, 9 months. Mean age for the deaf subjects was 12 years, 5 months. Hearing children ranged in age from 8 years, to 18 years, 1 month. Mean age for this group was 13 years, 5 months (see Table 1).

Following testing, the results of six subjects were discarded because three deaf subjects were administered tactual-successive response choices in lieu of auditory-successive choices when it was determined that they were

TABLE 1

SUBJECTS DESCRIBED BY SEX

AND CHRONOLOGICAL AGE

| Group | Condition | Sex | | Age Range | Mean Chrono- logical Age |
		Male	Female		
D E A F	VIS-SIM	8	3	8 years 6 months to 18 years 9 months	12 years 5 months
	VIS-SUC	6	5		
	TAC-SUC	4	7		
H E A R I N G	VIS-SIM	6	5	8 years to 18 years 1 month	13 years 5 months
	VIS-SUC	6	5		
	TAC-SUC	4	7		

unable to hear the buzzes. The results of their yoked controls were deleted from the sample as well. This left a remainder of 66 subjects in the final analysis.

Design

The design of this investigation is presented in Figure 3, showing a breakdown of groups and conditions. As can be seen in the Figure, two groups of subjects varying in degree of hearing loss--none or profound--were employed. Also, three conditions of stimulus presentation were used: visual-simultaneous, visual-successive, and tactual-successive. The response choice modality was varied as a within-subject variable consisting of five levels: visual-simultaneous, visual-successive, auditory-successive, tactual-successive and tactual-simultaneous. Specific hypotheses were tested by comparing cells across groups or conditions within a group or condition, as determined by the predicted effects of the hypotheses.

Apparatus

Eight different apparatus components were involved in carrying out the entire experiment, but only six were displayed to any subject. The components were arranged in a square configuration such that the subject was seated in the center (see Figure 4).

Inspection stimuli in the visual modes were situated directly in front of the subject on a table

RESPONSE CHOICES

STIMULI	DEAF		Visual-simultaneous	Visual-successive	Auditory-successive	Tactual-successive	Tactual-simultaneous
		Visual-simultaneous					
		Visual-successive					
		Tactual-successive					

RESPONSE CHOICES

INSPECTION	HEARING		Visual-simultaneous	Visual-successive	Auditory-successive	Tactual-successive	Tactual-simultaneous
		Visual-simultaneous					
		Visual-successive					
		Tactual-successive					

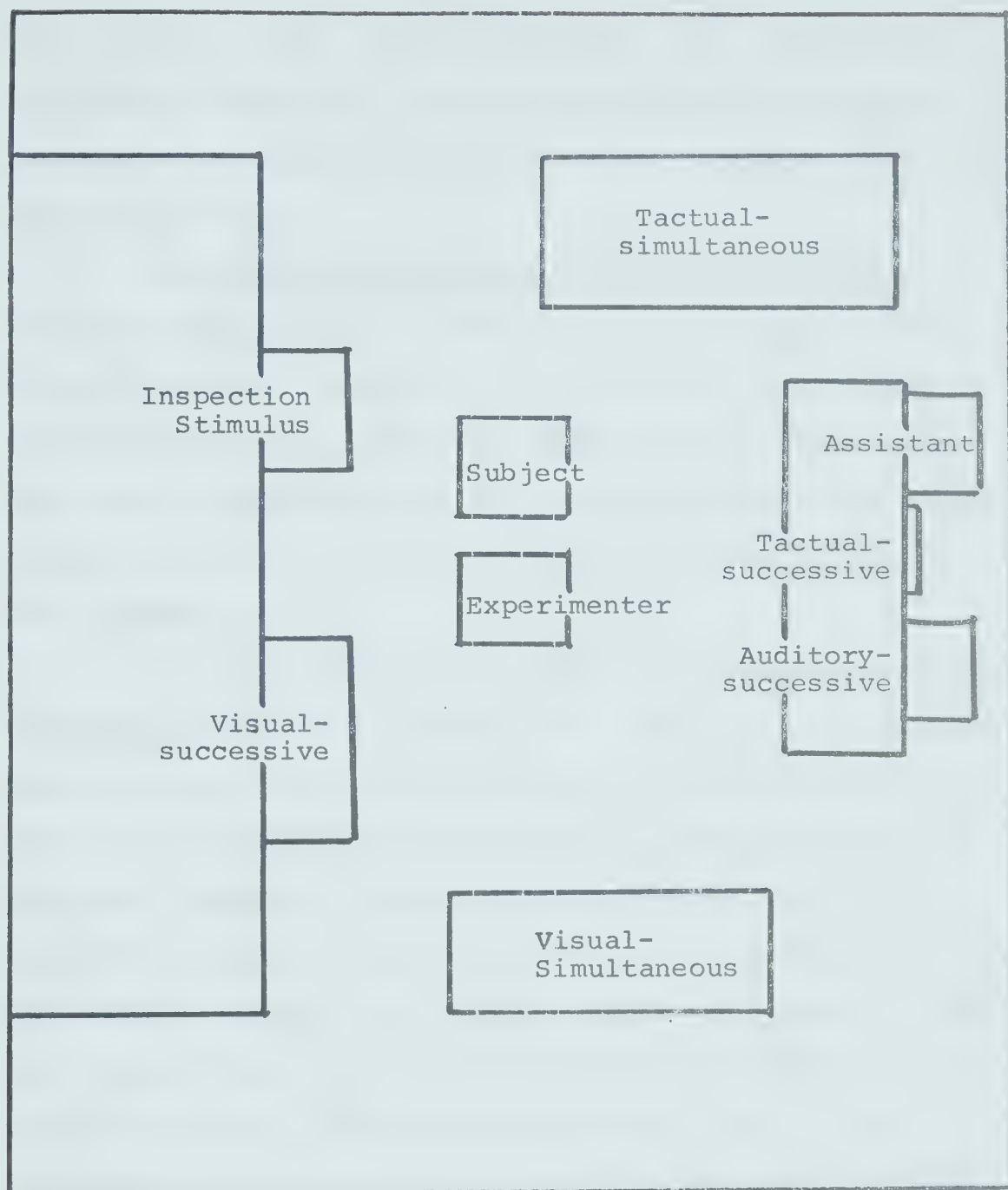Fig. 3.--Design of the investigation.

Fig. 4.--Schematic view of apparatus.

29 1/2 inches high. Since a response choice apparatus
was also on this table, inspection stimuli were always
elevated to a position above the choice stimulus (12 inches
above the table).

(1) Visual-simultaneous inspection stimulus
apparatus consisted of a black felt board 9 by 22 inches.
White felt dots, 3 inches in diameter, were positioned on
the felt board in a horizontal arrangement. These dots
were easily manipulated by the experimenter so that presen-
tations could be varied throughout the course of testing
(see Figure 5).

(2) For those subjects who were exposed to a visual-
successive inspection stimulus, the felt board was removed
from the table and replaced by a light bulb apparatus.
This 40-watt blue bulb, fitted into a fixture with wiring
threaded through a 3 1/2- by 11-inch wooden board, was
controlled remotely by the assistant who was seated behind
the subject (control box 8 by 5 inches). Flashes of light
were varied according to the frequency and duration of the
switch-pressing. All of the light bulbs used in the
experiment were blue in color so that the subjects would
have no difficulty distinguishing the stimuli from the white
light in the room. Forty watts seemed to be a comfortable
magnitude at which to perceive the stimuli, based on pilot
testing.
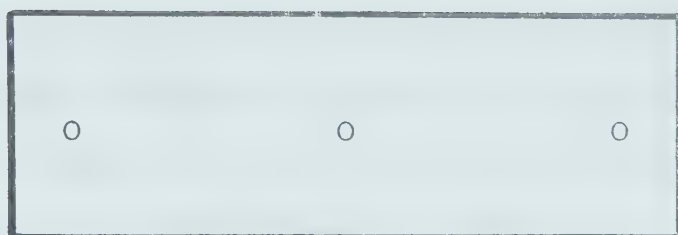
Rectangle=field
O=stimulus

Fig. 5.--Stimulus distribution used in presentations.

(3) When subjects were to be presented with a tactual-successive inspection stimulus, the table was cleared of all other inspection stimuli. The subject was then tapped on the back by the assistant who was seated behind him, with a 12-inch plastic hammer (see Figure 5c).

The five different Response Choices exposed to all subjects were displayed around the subject within the square configuration described in Figure 4.

(1) The visual-successive response choice component rested on the table described earlier. This apparatus consisted of three 40-watt bulbs each encased in fixtures which fitted into a 3 1/2- by 24-inch wooden base. Each bulb was labelled with an appropriate number: 1, 2 or 3 ("1" on the left, "2" in the center, "3" on the right). Wires 11 feet long stemming from each bulb were threaded through the base, meeting behind the subject at a control box having three corresponding switches. This allowed the assistant to control the frequency and duration of the lights remotely.

(2) The visual-simultaneous response choice apparatus was set on the wall to the left of the subject. This consisted of a large piece of cardboard 31 inches high, 22 inches in diameter, upon which were stapled three pieces of black felt. Stimuli consisted of white felt dots indentical to those used for the inspection stimulus. Response choices were labelled 1, 2 and 3 ("1" at the top,

"2" in the center, "3" at the bottom). A divided curtain suspended from a portable frame was 5 1/2 feet high and set 2 feet in front of the stimulus board. This allowed the experimenter to stand behind the curtain and change the order of stimuli throughout the testing. At prescribed times, the experimenter opened the curtain to expose the choice stimuli to the subject (see Figure 5).

(3) A third response choice component for auditory-successive choices consisted of a Beltone Model 10-D audiometer controlled by the assistant. The subject was fitted with earphones and fed buzzes of varying frequencies and durations at a decibel level that was comfortable and audible to whichever ear was superior. First, second and third response choices were distinguised by numbers held up before the subject, by the experimenter, prior to each presentation .

(4) Tactual-successive response choices were provided in the following manner. The subject was tapped on the back by the assistant who was seated behind him, with a 12-inch plastic hammer. They were distinguished from the inspection stimulus by numbers (1, 2 and 3) which were held up before the subject by the experimenter, prior to each presentation. Positioning of each presentation on the subject's back varied so that no confounding effects (such as pressure on one point of the body) would interfere with responses.

(5) The final component for tactual-simultaneous response choices consisted of a wooden frame 25 inches by 27 inches by 14 inches. The frame was elevated in its position facing the subject, declining in a diagonal towards its end. At both its top and front, the frame was covered by opaque curtains. This allowed the subject to extend both hands through the front curtain into the apparatus and move his hands from one response choice to another without seeing any of them. The top end of the apparatus was covered by another opaque curtain which was easily lifted to allow the experimenter to put head and hands beneath the curtain and periodically change the order of the response choices. Each choice was numbered on the curtain above it ("1" nearest to subject, "2" in the center, "3" at the far end).

Description of Stimulus Materials

The experiment consisted of nine different kinds of inspection stimuli including all presentations for all groups; three different kinds for each subject. Inspection and response choice stimuli varied according to (a) modality of input (visual, auditory or tactual), (b) condition (simultaneous or successive) and (c) pattern (frequency or spatial distribution) of exposures.

Basically there were three possible patterns represented visually and spatially here:

(1) .   .   .

(2) ..   .

(3) .   ..

(1) The felt dots used in the <u>visual-simultaneous</u>
presentation were 3 inches in diameter and distributed
5 inches apart in a configuration such as (1) above. In
the second pattern the first two dots were 1 inch apart
with 9 inches between the second and third dot. The
third pattern had 9 inches between the first and second
dots and 1 inch between the second and third. These
measurements were the same for both simultaneous inspection
and response choice stimuli. The visual-simultaneous
inspection stimulus was exposed for 7 seconds. Response
choice exposures remained displayed until the subject
indicated that he had made his choice.

(2) The <u>visual-successive</u> inspection and response
choice stimuli, which consisted of 40-watt blue light
bulbs (8 inches between bulbs in response choice), displayed
a pattern by means of a temporal distribution of flashes.
The assistant counted out a succession of numbers by
thousands. Pattern (1) above was counted in the following
manner: the experimenter silently counted "One thousand one,
one thousand two, one thousand three, one thousand four,
one thousand five, one thousand six, one thousand seven."
It took approximately one second to count each number,
and lights were flashed at the counts of 1,001; 1,004 and

1,007. Therefore, pattern (1) was exposed for 7 seconds.
Pattern (2) could be represented by the experimenter's
counting between 1,001 and 1,006; flashing the light at
the counts of 1,001; 1,003 and 1,006. Pattern (2) thus
took 6 seconds to expose. For pattern (3) lights were
flashed at the counts of 1,001; 1,004 and 1,006; as the
experimenter counted between 1,001 and 1,006. Both
inspection stimulus and response choice stimuli of a
visual-successive nature were exposed in this manner.

(3), (4) Similarly, tactual-successive
(inspection stimuli and response choices) and auditory-
successive (inspection stimuli and response choices) were
presented to the subject. For deaf subjects, the decibel
level was always above the speech threshold; for hearing
subjects 25 db. was standard.

(5) The tactual-simultaneous patterns were
spatially distributed in the following manner:

    (a) Pattern (1)

    (b) Pattern (2)

    (c) Pattern (3)

Wooden knobs were 2 inches in diameter and distributed on
three masonite boards, 7 inches by 25 inches, each of which
fit into the base of the apparatus. The choices were
efficiently varied by simply lifting the boards by their
knobs and placing them in their appropriate slot. Distrib-
utions were all determined in pilot testing.

Description of Task

The experimental treatments. Essentially, the
testing consisted of three different tasks ([a] visual-
simultaneous, [b] visual-successive and [c] tactual-
successive) involving three different groups of subjects.
All tasks involved transfer from an inspection stimulus
of a particular mode and condition to five different
response choices. Each response choice was repeated six
times bringing the total number of trials for each subject
to 30. Transfer occurred both intra-modally and cross-
modally, depending on the nature of the inspection stimulus
and the response choice. In all cases, the order of the
response choices was randomly alternated to control for
order effect.

Task (a). Subjects receiving this task were shown
a visual-simultaneous inspection and required transfer to
visual-simultaneous, visual-successive, tactual-simultaneous,
tactual-successive and auditory-successive response choices.
The only memory load was in the order of the three items of
the inspection stimulus. Subjects were required to retain
the stimulus arrangement and match this to the three response
choices until a decision of match was derived. Following
all three response choices, subjects indicated to the
experimenter the response that matched the inspection
stimulus, by responding "One," "Two," or "Three." The three

possible arrangements for inspection stimuli were randomized so that not more than three of the same occurred in succession. The subjects were expected to respond for 30 trials of this task.

Task (b). All subjects involved in this task received a visual-successive inspection stimulus and were required to transfer to visual-simultaneous, visual-successive, tactual-simultaneous, tactual-successive and auditory-successive response choices. Subjects were required to retain the stimulus arrangement and match this to the three response choices until a decision of match was derived. Following all three response choices, subjects indicated to the experimenter, the response that matched the insepction stimulus, by responding "One," "Two," or "Three." The subjects were expected to respond for the 30 trials presented.

Task (c). Subjects received a tactual-successive stimulus on each trial. This was followed by visual-simultaneous, visual-successive, tactual-simultaneous, tactual-successive and auditory-successive response choices presented over 30 trials in a random order. Subjects were required to retain the stimulus arrangement and match this to the three response choices until a decision of match was derived. Following all three response choices, subjects indicated to the experimenter the response that

matched the inspection stimulus, by responding "One,"
"Two," or "Three."

Procedure

All deaf subjects were tested in the same room at
the Alberta School for the Deaf, since the residential
students come from parts of the Province other than
Edmonton and would not be available on weekends. Subjects
were easily removed from their dormitories for the testing
and thus more accessible to the experimenter. Hearing
subjects were tested in a room at the University of Alberta,
which was more accessible by public transportation than
the Alberta School for the Deaf.

Prior to each task all subjects were given instruc-
tions by the experimenter. Although the instructions were
conveyed verbally for hearing subjects and manually for
deaf subjects, both were accompanied by demonstration using
the apparatus and samples of task procedure. Equivalence
of modalities and conditions of presentation was demon-
strated by the experimenter in the following manner:
(a) Subjects were first introduced to the apparatus by a
short demonstration of how each part would function in the
testing. (b) The experimenter next held a closed fist in
front of the light bulb component, opening the fist and
extending the fingers outward when the bulb was flashed,
thus indicating the "flash" to deaf subjects. Hearing

subjects were told the word "flash" verbally. (c) A pause (temporal delay in flash) between the second and third flash was indicated by the manual sign "wait" for deaf subjects; the verbal word "pause" for hearing subjects. (d) Subjects were next shown the three visual-simultaneous response choices and were directed to focus on the choice that was equivalent to the inspection stimulus. The experimenter then repeated the earlier demonstration: "Flash, flash, wait (pause), flash." But at the point of "wait (pause)" the experimenter's two hands were separated in a horizontal movement across the blank space and accompanying this gesture with the sign "wait" for the deaf, and the verbal "pause" for the hearing, thus equivocating the temporal dimension of non-flashing to the negative spatial dimension. The experimenter then told the subjects that the inspection stimulus and that particular response choice were the same; that the other two response choices differed from the inspection stimulus. The subject was asked if he understood. If he responded in the negative, the demonstration was repeated a maximum of two more times until the subject indicated an understanding. Subjects who did not understand the final explanation were stopped and did not participate in the rest of the experiment. Six deaf subjects were dropped during testing. All hearing subjects participated throughout all the testing.

Following the demonstration the experimental
trials were begun. Each subject was asked to attend to
the inspection stimulus and try to remember what he saw
and find the one that was the same among the response
choices, indicating to the experimenter whether this was
number one, two or three. No strategy for remembering the
stimulus was offered. Prior to each trial subjects were
told that they should attend first to the inspection
stimulus and then to the part of the apparatus involved in
that particular trial.

The subject was then presented with the 30 trials.
He was given feedback only during the demonstration; in all
other cases the experimenter responded with "Okay," or
repeated the response choice number to indicate that she
had received the subject's decision and would go on.

Recording of Data

Data were recorded during the course of testing by
the experimenter. This was done by observing (in the case
of the deaf subjects) the response (one, two or three) of
the subject, or listening (in the case of the hearing
subjects) to the subject's response and placing a check-
mark on the data recording sheet next to the response that
corresponded to that of the subject. A copy of the data
recording sheet is provided in Appendix A.

Scoring

Scoring was done by hand after all the data had been collected. Each response choice was matched to the inspection stimulus presented for each trial and data were collated across experimental conditions.

CHAPTER V

RESULTS

The results of the experimental investigation were
analyzed according to the specific hypothesis presented
previously in Chapter III. In order to assess these
hypothesized effects the $\underline{t}$ test and analysis of variance
techniques (Glass & Stanley, 1970, pp. 292-445) were
employed. Table 2 presents the general design of the
investigation, a 2 x 3 x 5 factorial design with the third
variable being within-subject, along with the means and
standard deviations for correct matching responses on the
experimental task (see Table 2). This table portrays the
conditions for inspection stimulus modality and response
choice modalities which were contrasted in the hypothesized
comparisons. The tests of each hypothesis will make
reference to the comparisons as the conditions are presented
in this table.

Hypothesis 1

The first hypothesis predicted that hearing sub-
jects would produce more correct responses than their
deaf counterparts on tasks which involved stimulus pre-
sentation in a modality (auditory or tactual) or condition
(successive presentation) in which they lacked experience.

The specific predictions follow. They are quoted as they appear in Chapter III.

> Hypothesis 1.1. Hearing subjects will produce more total correct responses than deaf subjects on all successive tasks.

In order to test this hypothesis, hearing subjects were compared to deaf subjects on a composite mean score of all cells in Table 2 except the visual-simultaneous to visual-simultaneous and visual-simultaneous to tactual-simultaneous conditions. The t test for independent samples was employed indicating a significant difference between the two groups ($\overline{X}$ Hearing=23.42, $\overline{X}$ Deaf=18.79, t=3.20, df=32) at the .001 level. The results thus support the hypothesis in the predicted direction. A post-hoc analysis comparing the deaf and hearing subjects on the visual-simultaneous to visual-simultaneous transfer revealed no significant difference between the two groups on this condition ($\overline{X}$ Hearing=5.82, $\overline{X}$ Deaf=5.45, t=1.18, df=10, p>.05).

> Hypothesis 1.2. Deaf subjects will produce more total correct responses on successive response choices in the visual mode than in the tactual and auditory modalities.

This hypothesis was tested by comparing a composite score of the visual-successive response choice mode with the composite of the six cells in the tactual and auditory-successive response choice modes. A t test for dependent samples was employed which indicated a significant difference between the groups ($\overline{X}$ visual-successive=4.48, $\overline{X}$ auditory-successive and tactual-successive=4.09,

TABLE 2

MEANS AND STANDARD DEVIATIONS FOR TOTAL CORRECT
MATCHING CHOICE RESPONSES FOR SIX TRIALS COMPARING
HEARING SUBJECTS ON INSPECTION STIMULUS AND RESPONSE
CHOICE MODES

Group	Inspection stimulus condition	Response Choice Conditions				
		Visual-simultaneous	Visual-successive	Auditory-successive	Tactual-successive	Tactual-simultaneous
Deaf children	Visual-simultaneous	5.45 (.82)	4.36 (1.86)	3.72 (1.49)	4.27 (1.62)	4.18 (1.40)
	Visual-successive	4.90 (1.22)	3.90 (1.87)	3.90 (1.45)	4.27 (1.19)	3.54 (1.51)
	Tactual-successive	5.72 (.65)	5.18 (.75)	4.45 (1.57)	3.90 (1.38)	4.18 (1.25)
Hearing children	Visual-simultaneous	5.81 (.60)	5.54 (.93)	5.63 (.67)	5.81 (.40)	5.00 (1.22)
	Visual-successive	5.72 (.47)	5.45 (.69)	5.36 (.81)	5.09 (.70)	4.72 (1.01)
	Tactual-successive	5.45 (.69)	5.72 (.47)	5.45 (.69)	5.18 (1.25)	5.09 (1.14)

Note.--Numbers in parentheses are standard deviations.

t=1.79, df=32) at the .041 level. The results support the hypothesis in the predicted direction.

> Hypothesis 1.3. There should be a learning trend for the deaf on all transfer tasks due to the subjects' ability to improve on these tasks as a result of experience with the task.

This hypothesis was assessed with a one-factor, repeated measure, analysis of variance procedure in which the deaf subjects data were collapsed across both inspection stimulus and response choice conditions. In this analysis, the data were assessed across the six trials for each response choice condition which served as the six levels of the repeated measures. The means and standard deviations are presented in Table 3 for the six trial averages across these conditions. The analysis of variance revealed a significant difference between these trials (F=3.77, df_1=5, df_2=300) at the .01 level supporting the above hypothesis regarding an increase in accuracy of matching for the deaf subjects during the course of the experiment.

> Summary of findings for Hypothesis 1. All three predictions in Hypothesis 1 were statistically significant. Hypothesis 1.1 was confirmed in that hearing subjects did significantly better than deaf subjects on all successive tasks. Hypothesis 1.2, which predicted that deaf subjects would produce more correct responses on successive tasks in the visual mode than in the tactual and auditory modes, was supported by the findings. Finally, Hypothesis 1.3, which predicted a learning trend for the deaf on all transfer tasks, was confirmed.

TABLE 3

MEANS FOR DEAF SUBJECTS

FOR THE SIX TRIALS

COLLAPSED ACROSS INSPECTION STIMULUS

AND RESPONSE CHOICE CONDITIONS

Item	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Means	.642	.727	.739	.727	.770	.794
Standard Deviation	(.481)	(.447)	(.440)	(.447)	(.422)	(.410)

Hypothesis 2

The second hypothesis predicted first that deaf and hearing subjects would produce more correct responses on tasks involving transfers to and from modality-congruent stimulus distributions (e.g., visual-spatial and auditory-temporal) than modality-incongruent distributions; secondly that subjects who have experience with a condition of a modality-incongruent (e.g., visual-successive, tactual-simultaneous) stimulus distribution will produce more correct responses than subjects lacking such experience. The specific predictions follow, quoted from Chapter III.

> Hypothesis 2.1. Both deaf and hearing subjects will produce more total correct responses on transfers from visual-simultaneous to visual-simultaneous than from visual-simultaneous to visual-successive distributions.

A t test for dependent samples was performed for these two conditions which resulted in a significant difference ($\bar{X}$ visual-simultaneous to visual-simultaneous=5.64, $\bar{X}$ visual-simultaneous to visual-successive=4.95, t=2.06, df=21) at the .026 level. The results thus supported this hypothesis in the predicted direction.

> Hypothesis 2.2. Both deaf and hearing subjects will produce more total correct responses on transfers from visual-simultaneous to tactual-successive than from visual-simultaneous to tactual-simultaneous distributions.

A t test for dependent samples comparing these two conditions across both groups was performed. The results of the analysis ($\bar{X}$ visual-simultaneous to tactual-

successive=5.05, $\overline{X}$ visual-simultaneous to tactual-

simultaneous=4.59, t=1.36, df=21) do not support this hypo-

thesis.

 Hypothesis 2.3. Both deaf and hearing subjects
will produce more total correct responses on transfers
from tactual-successive to tactual-successive than
from tactual-successive to tactual-simultaneous
distributions.

A t test for dependent samples was performed collapsed

across both groups of subjects comparing these conditions.

The results of the analysis do not support this hypothesis

($\overline{X}$ tactual-successive to tactual-successive=4.55,

$\overline{X}$ tactual-successive to tactual-simultaneous=4.64, t=.34,

df=21).

 Hypothesis 2.4. Both deaf and hearing subjects
will produce more total correct responses on transfers
from tactual-successive to visual-simultaneous than
from tactual-successive to visual-successive distrib-
utions.

A t test for dependent samples was performed on these two

conditions across both subject groups. The results of the

analysis do not support this hypothesis ($\overline{X}$ tactual-

successive to visual-simultaneous=5.59, $\overline{X}$ tactual-

successive to visual-successive=5.45, t=.65, df=21).

 Hypothesis 2.5. Both deaf and hearing subjects
will produce more total correct responses on transfers
from tactual-successive to auditory-successive than
from tactual-successive to tactual-simultaneous
distributions.

A t test for dependent samples was performed comparing

these conditions. The results of the analysis do not

support this hypotheses ($\overline{X}$ tactual-successive to auditory-

successive=4.95, $\overline{X}$ tactual-successive to tactual-simultaneous=4.64, t=.94, df=21).

Hypothesis 2.6. Both deaf and hearing subjects will produce more correct responses on transfers from visual-successive to visual-simultaneous than from visual-successive to tactual-simultaneous distributions.

A t test for independent samples was performed which resulted in a significant difference ($\overline{X}$ visual-successive to visual-simultaneous=5.32, $\overline{X}$ visual-successive to tactual-simultaneous 4.59, t=2.08, df=21) at the .024 level. The results thus supported this hypothesis in the predicted direction.

Hypothesis 2.7. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-simultaneous to auditory-successive distributions.

A t test for independent samples was performed comparing these groups which resulted in a significant difference ($\overline{X}$ Hearing=5.64, $\overline{X}$ Deaf=3.73, t=3.87, df=10) at the .001 level. The results supported this hypothesis in the predicted direction.

Hypothesis 2.8. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-simultaneous to tactual-successive distributions.

A t test for independent samples was performed between the groups which resulted in a significant difference ($\overline{X}$ Hearing=5.82, $\overline{X}$ Deaf=4.27, t=3.07, df=10) at the .005 level. The results thus supported this hypothesis in the predicted direction.

Hypothesis 2.9. Hearing subjects will produce
more total correct responses than deaf subjects on
transfers from tactual-successive to visual-
successive distributions.

A $\underline{t}$ test for independent samples was performed for this

comparison which resulted in a significant difference

($\overline{X}$ Hearing=5.73, $\overline{X}$ Deaf=5.18, t=2.05, df=10) at the .033

level. The results thus supported this hypothesis in

the predicted direction.

Hypothesis 2.10. Hearing subjects will produce
more total correct responses than deaf subjects on
transfers from tactual-successive to auditory-
successive distributions.

A t test for independent samples was performed on these

conditions which resulted in a significant difference

($\overline{X}$ Hearing=5.45, $\overline{X}$ Deaf=4.45, t=1.93, df=10) at the .041

level. The results thus supported this hypothesis in

the predicted direction.

Hypothesis 2.11. Hearing subjects will produce
more total correct responses than deaf subjects on
transfers from visual-successive to visual-successive
distributions.

A t test for independent samples was performed between these

groups which resulted in a significant difference

($\overline{X}$ Hearing=5.45, $\overline{X}$ Deaf=3.91, t=2.57, df=10) at the .013

level. The results supported this hypothesis in the

predicted direction.

Hypothesis 2.12. Hearing subjects will produce
more total correct responses than deaf subjects on
transfers from visual-successive to auditory-
successive distributions.

A $\underline{t}$ test for independent samples was performed which

resulted in a significant difference ($\overline{X}$ Hearing=5.36,

$\overline{X}$ Deaf=3.91, t=2.91, df=10) at the .007 level. The results

thus supported this hypothesis in the predicted direction.

Hypothesis 2.13. Hearing subjects will produce
more total correct responses than deaf subjects on
transfers from visual-successive to tactual-successive
distributions.

A t test for independent samples was performed between these

groups which resulted in a significant difference

($\overline{X}$ Hearing=5.09, $\overline{X}$ Deaf 4.27, t=1.96, df=10) at the .038

level. The results thus supported this hypothesis in the

predicted direction.

Summary of findings for Hypothesis 2. The first

part of the second hypothesis (Hypotheses 2.1 through 2.5)

which stated that both deaf and hearing subjects would

produce more correct responses on tasks involving transfers

to and from modality-incongruent stimulus distributions was

generally not supported by the results. Hypothesis 2.1,

however, was confirmed in that both deaf and hearing sub-

jects performed significantly better on transfers from

visual-simultaneous to visual-simultaneous stimulus distrib-

utions than on transfers from visual-simultaneous to

visual-successive stimulus distributions. The second part

of Hypothesis 2 (Hypotheses 2.6 through 2.13) which stated

that subjects who have experience with a condition of a

modality-incongruent stimulus distribtuion would produce

more correct responses than those who do not have such

experience, was confirmed in each comparison.

Hypothesis 3

The third hypothesis predicted that on tasks requiring subjects to perceive stimuli in one modality and recognize the equivalent stimuli in a different modality, hearing subjects would show more accurate coding than deaf subjects. Table 4 shows the specific comparisons for each of these cross-modal transfers. The specific hypotheses, quoted from Chapter III, are assessed below.

> Hypothesis 3.1. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-simultaneous to auditory-successive distributions.

A t test for independent samples was performed for these groups which resulted in a significant difference ($\bar{X}$ Hearing=5.64, $\bar{X}$ Deaf=3.73, t=3.87, df=10) at the .001 level. The results thus supported the hypothesis in the predicted direction.

> Hypothesis 3.2. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-simultaneous to tactual-simultaneous distributions.

A t test for independent samples was performed for these groups. The results of the analysis do not support this hypothesis ($\bar{X}$ Hearing=5.00, $\bar{X}$ Deaf=4.18, t=1.44, df=10).

> Hypothesis 3.3. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-simultaneous to tactual-successive distributions.

A t test for independent samples was performed for these groups which resulted in a significant difference ($\bar{X}$ Hearing=5.82, $\bar{X}$ Deaf=4.27, t=3.07, df=10) at the .005

level. The results thus supported this hypothesis in the predicted direction.

Hypothesis 3.4. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-successive to auditory-successive distributions.

A t test for independent samples was performed which resulted in a significant difference ($\overline{X}$ Hearing=5.36, $\overline{X}$ Deaf=3.91, t=2.91, df=10) at the .007 level. The results thus supported this hypothesis in the predicted direction.

Hypothesis 3.5. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-successive to tactual-simultaneous distributions.

A t test for independent samples was performed for these groups which resulted in a significant difference ($\overline{X}$ Hearing=4.73, $\overline{X}$ Deaf=3.55, t=2.16, df=10) at the .028 level. The results thus supported this hypothesis in the predicted direction.

Hypothesis 3.6. Hearing subjects will produce more total correct responses than deaf subjects on transfers from visual-successive to tactual-successive distributions.

A t test for independent samples was performed between those groups which resulted in a significant difference ($\overline{X}$ Hearing=5.09, $\overline{X}$ Deaf=4.27, t=1.96, df=10) at the .038 level. The results thus supported this hypothesis in the predicted direction.

Hypothesis 3.7. Hearing subjects will produce more total correct responses than deaf subjects on transfers from tactual-successive to visual-simultaneous distributions.

TABLE 4

COMPARISON OF DEAF AND HEARING

SUBJECTS ON VARIOUS CROSS-MODAL TRANSFERS

Transfer	Deaf Mean	Pooled s	Hearing Mean	t Value	df	p
Visual-simultaneous to Auditory-successive	3.72	1.15	5.63	3.87	10	.001
Visual-simultaneous to Tactual-simultaneous	4.18	1.33	5.00	1.43	10	.09
Visual-simultaneous to Tactual-successive	4.27	1.17	5.81	3.07	10	.005
Visual-successive to Auditory-successive	3.90	1.17	5.36	2.91	10	.007
Visual-successive to Tactual-simultaneous	3.54	1.28	4.72	2.16	10	.028
Visual-successive to Tactual-successive	4.27	.977	5.09	1.96	10	.038
Tactual-successive to Visual-simultaneous	5.72	.667	5.45	.95	10	.180
Tactual-successive to Visual-successive	5.18	.625	5.72	2.04	10	.033
Tactual-successive to Auditory-successive	4.45	1.21	5.45	1.93	10	.041

A $\underline{t}$ test for independent samples was performed between
these groups. The results of the analysis do not support
this hypothesis ($\overline{X}$ Hearing=5.45, $\overline{X}$ Deaf=5.73, t=.96,
df=10).

Hypothesis 3.8. Hearing subjects will produce
more correct responses than deaf subjects on
transfers from tactual-successive to visual-successive
distributions.

A $\underline{t}$ test for independent samples was performed for these
conditions which resulted in a significant difference
($\overline{X}$ Hearing=5.73, $\overline{X}$ Deaf=5.18, t=2.05, df=10) at the .033
level. The results thus supported the hypothesis in the
predicted direction.

Hypothesis 3.9. Hearing subjects will produce
more total correct responses than deaf subjects on
transfers from tactual-successive to auditory-
successive distributions.

A $\underline{t}$ test for independent samples was performed which
resulted in a significant difference ($\overline{X}$ Hearing=5.45,
$\overline{X}$ Deaf=4.45, t=1.93, df=10) at the .041 level. The results
thus supported this hypothesis in the predicted direction.

Summary of findings for Hypothesis 3. This hypo-
thesis (Hypotheses 3.1 through 3.9) was generally supported
by the results in that in all but two comparisons the
hearing subjects produced significantly more correct
responses on cross-modal transfers than the deaf subjects.
Hypothesis 3.2 which predicted that hearing subjects would
perform in a manner superior to deaf subjects on transfers
from visual-simultaneous to tactual-simultaneous stimulus

distributions and Hypothesis 3.7 which predicted that hearing subjects would produce more correct responses on transfers from tactual-successive to visual-simultaneous stimulus distributions were not confirmed by the results, i.e., no significant differences were revealed.

CHAPTER VI

DISCUSSION

The Hypotheses

Hypothesis 1. The underlying assumption of this
study was that perceptual processes for hearing and deaf
children would differ only in those areas of processing
where the deaf are restricted in perceptual experiences
that are available to the hearing. It was proposed in
Hypothesis 1 that the deaf and hearing subjects' responses
to the stimulus materials in the various conditions would
vary relative to their experience with processing analogous
material. Since it is the case that experience with
successive processing is gained primarily through the
auditory modality, it was predicted that hearing subjects
produce more correct responses than the deaf subjects on
transfer tasks involving these successive conditions. The
results of the subjects' performance on successive tasks
which tested this prediction supported the first hypothesis
in the predicted direction. The performance of hearing
subjects was superior to that of the deaf subjects on
successive tasks. This reasoning was extended to suggest
that there would be no significant differences between the
deaf and hearing on tasks involving modalities and

conditions in which both groups were equally experienced.
A post-hoc analysis revealed that indeed there were no
significant differences between these groups on transfers
from visual-simultaneous distributions to visual-
simultaneous distributions. Further support for this
hypothesis was evidenced in the results of Hypothesis 1.2,
wherein deaf subjects produced significantly more correct
responses on successive response choices in the visual
mode than in the tactual and auditory modalities. In
this instance an unfamiliar condition (successive) was
associated with three different modalities and as pre-
dicted the deaf did significantly better on response
choices in the visual-successive modality than in the
tactual-successive and auditory-successive modality.
These results indicated that the visual modality is one
that for the deaf is superior to the others regardless of
condition. From the above we can conclude that the modal-
ity with which the deaf have most experience is also the
modality most suited for making decisions of equivalence
in same or different modalities. The import of such
results lies in the earlier analysis of the reading pro-
cess and the search for an explanation of the high
incidence of reading retardation among the deaf. A primary
deficiency in successive processing would imply that the
deaf would have difficulty in what Lashley (1960) has
described as the hierarchy of integrations involved in the

expression of language. Paivio's (1971) proposal that the verbal system is specialized for the processing of temporally organized patterns would suggest that inferior processing of successive stimuli would be cause for a disturbance in the verbal system. If we consider deaf children who are taught in a manner similar to hearing children, involving the transfer from and to successive stimuli, then the problems of the deaf, manifested in the form of reading retardation, could at least partially be explained by the fact that the deaf have difficulty with processing and transferring successive information. It is also evident that to teach the deaf in such a manner would be to least exploit the modality and condition in which they are most successful and most like their hearing peers--that is the visual-simultaneous modality and con- dition. The results appear to conclusively identify the visual-simultaneous to visual-simultaneous transfers and visual-simultaneous response choices as the strongest in- put and response modes for deaf recipients.

The results of the analysis for the third part of Hypothesis 1 revealed a learning trend over the six presentations in all conditions for the deaf subjects. These findings suggest that if we would attempt to teach students on tasks involving intersensory integration (language and reading for the deaf), repeated exposure to stimuli of that nature could probably enhance the effec-

tiveness of training. As Shagan puts it, "The critical
variable is not the modality per se but the degree of
experience in working with a modality [Goodnow, 1971,
p. 4]."

Hypothesis 2. The second hypothesis first pre-
dicted that deaf and hearing subjects would perform in a
superior fashion on tasks involving modality-congruent
stimulus distributions than to tasks involving modality-
incongruent distributions. In general, this part of the
hypothesis was not supported by the results. There were
no significant differences between transfers that involved
modality congruent conditions in comparison to modality-
incongruent conditions. It appears that these results
suggest only that modality-congruency will not necessarily
simplify the problem of transfer. Although these results
might lead one to suspect that simultaneous distributions
are not necessarily apprehended most easily through
through the visual modality and successive distributions
are not perceived best by the auditory and tactual modal-
ities as O'Connor and Hermelin have proposed (1971), caution
should be heeded before arriving at such an interpretation.
It is more probable that this study involved a procedure
that was not an adequate test of this hypothesis. These
findings suggest that it is likely that skill in learning
to read and manipulate language symbols is dependent on
perceiving stimuli through the most receptive modality

but not necessarily the case that transfer from one
modality to another is facilitated by modality congruency.

A second part of Hypothesis 2 predicted that the
hearing subjects would produce more correct responses
than the deaf subjects on transfers from and to modality-
incongruent conditions in which the deaf lacked experience.
This hypothesis was in all cases confirmed which lent
further support to the notion that experience would
facilitate transfer. That is, experience in both simul-
taneous and successive processing appears to be essential
for the transfer from and to modality-incongruent stimuli.
The deaf subjects, having a less substantial foundation of
successive processing experiences appear to have greater
difficulty than the hearing subjects in the transfer of
successive information within a modality-incongruent
context.

Hypothesis 3. The final hypothesis was supported
in all but two instances. Based on responses of both deaf
and hearing subjects on cross-modal as well as cross-
condition transfer, results have shown that there are
significant statistical differences between individuals
whose sensory receptors are normal and those who experience
a sensory deficit. Hearing subjects produced more correct
responses on the following cross-modal and cross-condition
transfers: visual-simultaneous to auditory-successive,
visual-simultaneous to tactual-successive, visual-successive

to auditory-successive, visual-successive to tactual-
simultaneous, visual-successive to tactual-successive,
tactual-successive to visual-successive and tactual-
successive to auditory-successive.

Because language learning (in terms of competence
and performance) for the deaf, is dependent on an ability
to recognize as well as arrange patterns of stimuli into
spatial and temporal arrangements, intra-modally and cross-
modally, the support of Hypothesis 3 is a significant
finding. On the task designed to test this hypothesis the
deaf subjects demonstrated greater difficulty than hearing
subjects, with the integration of stimuli received in one
modality and one particular condition to be perceived in
another or same modality and condition. The literature
has evidenced that essential to linguistic and reading
ability is a basic ability to code stimulus information
across modalities and conditions. Inasmuch as reading is
dependent on the ability to make judgements of auditory-
visual equivalence and, "a primary disturbance in the
ability to integrate stimuli from two critical sense
modalities, hearing and vision, may well serve to increase
the risk of becoming a poor reader [Birch & Belmont, 1964,
p. 858]," the findings of the present study suggest that
the poor intersensory performance by deaf subjects is at
least in part a factor which can account for reading
retardation among the deaf; this proposal would be the

case when reading is taught to the deaf in an analogous
fashion as it is taught to hearing children. Birch and
Belmont (1964) have proposed that other factors may also
account for reading incompetence; e.g., "emotional
disturbances, cultural deprivation, disturbances in
lateralization of function and other indicators of
neurologic dysfunction . . .[p. 860]."

The failure to find support for two specific
predictions, namely Hypothesis 3.2, which predicted that
hearing subjects would produce more correct responses than
deaf subjects on transfers from visual-simultaneous to
tactual-simultaneous distributions, and Hypothesis 3.7,
which predicted that hearing subjects would produce more
correct responses than deaf subjects on transfers from
tactual-successive to tactual-simultaneous distributions,
might be explained by the fact that both deaf and hearing
groups share equally in experience with visual-simultaneous
distributions and inexperience with tactual-simultaneous
and tactual-successive distributions of stimuli. The task
of transferring from a modality-congruent inspection
stimulus to a modality-incongruent response choice proved
to be equally as difficult for both groups. The fact that
in all other cases, response of the hearing subjects on
transfer tasks were significantly better than those of the
deaf, with the exception of these two, implies something of
a paradigm for the viewpoint that sensory experience is
related to sensory performance.

The results of this investigation have identified the inability of deaf children to process auditory-successive information as cause for differential responses at cross-modal transfer tasks between deaf and hearing groups. Although memory is a factor necessary for solving intersensory problems in a multiple-choice condition, which could contribute to the results, the design of the experiment controlled for the possible interference of the factor by prior testing of deaf subjects with the Hiskey Nebaska Memory Test of Colors and Numbers. It is not likely that the results obtained could be attributed to a deficiency in memory. Yet the possibility that subjects' memory for sensory stimuli in one modality is superior or inferior to their memory for sensory stimuli in another modality could account for the significant differences in response choices. Because this study has not attempted to determine causes for the differences found, but has attempted only to identify them, it would be of interest to explore the memory factor with the deaf in future research.

Some non-empirical observations made during the course of testing led the experimenter to believe that apart from differences between groups, differences among subjects could perhaps be accounted for by the coding strategies adopted by some subjects. Goodnow discusses this concept aptly in the following:

> Equally, the difficulty with cross-modal matching may
> lie in a tendency to use different forms of coding for
> different material. One has the feelings for example,
> that young children are more likely to use number
> coding for a series of dots on a page than for a
> series of sounds (they have learned to count with
> visual material). Older children, however, give
> the impression of being more likely to use number
> codings for both kinds of stimuli. Finally, the
> young child may have particular difficulty with
> some cross-modal tasks. . . because he lacks the
> rules that convert one stimulus pattern into
> another [Goodnow, 1971, p. 23].

The design of the experiment did not permit empirical

testing of coding operations, but it was apparent that

several deaf subjects adopted a manual strategy. In

these cases the stimulus arrangement was manifested in

the subjects' hands. For example, a spatial or temoral

arrangement in which the stimulus was distributed such

that two contiguous dots or beeps were separated by a

spatial or temporal interval from a third, subjects raised

two fingers on one hand and one finger on the other. This

kind of strategy suggests a kind of manual mediation for

the solving of transfer problems. Manual mediation seemed

to have served as a short-term memory retainer for these

deaf subjects. The utility of this observation lies in

the possibility of initiating manual strategies in pro-

grams designed to train cross-modal transfer for the pur-

pose of teaching language and reading to the deaf.

Implications

The implications of the study just described,

generally lie in the area of education of the deaf;

specifically in the area of designing reading and language
programs. One suggestion for an instructional option in
this area is the use of sign language in teaching the deaf
child to read.

Although it has been suggested earlier in this
thesis that the existence of reading and language at all
is an achievement for the deaf child taught by an oral
method, the reader is directed to consider an alternative
to reading retardation. If the oral approach to the
teaching of reading is an overly complex procedure having
unrealistic expectations, then an alternative would seem
to be a simpler method of instruction.

A simpler method would involve placing the empha-
sis of language training on the visual mode and using
spatially distributed stimuli. Accomplishing this would
merely involve using sign language (a visual stimulus
spatially distributed) as an input to be processed by the
child. Obviously, we would want the child to respond and
this would require cross-modal transfer. But cross-modal
transfer would be to an equivalent condition; i.e., from
visual stimuli spatially distributed, to motoric responses
spatially distributed. Acquiring language and learning to
communicate would involve merely learning units of spatially
distributed information. Individual signs when combined
into sentences could provide the child with experiences in
serial ordering of meaningful units. Later, when the child

enters school, reading may involve transfer across modalities, but conditions of presentation would remain the same. Reading would entail learning to recognize visual-spatial units (words) as associated with visual and motoric units (signs) and with other visual-spatial units (concrete objects). At the time of school entrance the deaf child would also have developed to the point of being receptive to cross-modal transfer problem-solving (Birch & Belmont, 1965). Successive processing should not be neglected. However, acquisition of successive processing, as the results have shown, is not a developmental phenomenon for deaf children. Successive processing should be formally trained before the child is expected to exercise it. A training procedure would best begin with successive processing in the visual modality and other modalities introduced following mastery.

While this suggested method of teaching reading to deaf children differs from that used to teach hearing children, the characteristic simplicity of the operations involved is similar. It is hoped that such an approach to instructing reading would result in a minimal incidence of reading retardation among the deaf.

Future research. The logical next step after the study presented in this thesis would be a study examining subjects' responses to a pre-test, training

procedure and post-test set of tasks designed to measure
the effects of training on successive processing (parti-
cularly in the visual modality). If deaf subjects,
as predicted, improve on successive tasks following
training, further evidence would exist for proposing that
teachers of the deaf systematically provide such training
in their educational programs.

Another suggestion for future research is a
replication of Blank and Bridger's study (see the review
of the literature, Chapter II) describing cross-modal
equivalence and cross-modal concept utilizing deaf sub-
jects. The results of their experiment supported the
investigators' hypothesis which stated that language is
not necessary for problems involving CME, but essential
for CMC tasks. CME- and CMC-type tasks are implicit in
programs designed to teach deaf children to speak. It
would be of interest therefore, to conduct a similar
experiment involving pre-school deaf children whose verbal
experience is limited or negligible in hopes of determin-
ing whether or not (a) there is any indication that pre-
school deaf children are prepared to begin language
training that involves CMC tasks and (b) if the absence
of an auditory language base inhibits successful perform-
ance of CMC problems.

A third suggestion for further research is to
select deaf subjects so that there are an equal number

of subjects in each in each age bracket. Developmental
trends would thus become evident. Selection of subjects
in the experiment described in this thesis was not made
in this way due to the availability of subjects for
testing.

Summary

The present study sought to investigate
differences between two groups, one group comprised of
hearing-impaired children and the other comprised of
normal hearing children, based on their responses to
various intramodal, cross-modal, intracondition and
cross-condition tasks. In addition to differences between
groups, the study attempted to determine (a) the optimal
stimulus combination for the transfer of perceptual infor-
mation for deaf subjects and (b) whether or not repeated
exposure to tasks would result in improvement by deaf
subjects.

The literature regarding simultaneous and succes-
sive information processing and cross-modal transfer
suggested (a) that the sensory modalities at some level
of cortical operation are equivalent which could account
for the human ability to transfer perceptual information
across modalities and (b) the fact that experience with
simultaneous and successive stimulus distributions can be
acquired in one modality and transferred to a different
modality. It had been proposed that a hearing loss

precludes the reception of auditory stimuli and would
thus cause deaf children to have greater difficulty than
hearing children in processing perceptual information of
a successive nature. The implication of this suggestion
is that the difficulties manifested by the hearing-impaired
in linguistic and reading performance, when they are taught
in a traditionally oral method, could be attributed to a
basic deficiency in perceptual processing. It had been
hypothesized that the hearing subjects involved in this
study would demonstrate greater facility than deaf subjects
at cross-modal, cross-condition, and modality-incongruent
tasks but that deaf and hearing subjects would perform in
a like manner on tasks involving stimuli which the subjects
have experienced equally; i.e., visual-simultaneous to
visual-simultaneous transfers.

Thirty-three deaf and 33 hearing subjects were
randomly assigned to three different groups distinguished
by inspection stimulus modality and condition; visual-
simultaneous, visual-successive and tactual-successive.
All subjects were administered tests involving the same
five response choices: visual-simultaneous, visual-
successive and tactual-simultaneous. The results indicated
that there are significant differences between deaf and
hearing subjects on cross-modal and modality-incongruent
transfers but no difference on transfers from visual-
simultaneous to visual-simultaneous stimulus distributions.

The deaf subjects made fewer correct responses on all successive tasks than hearing subjects. However, analysis of the responses made by deaf subjects revealed a learning trend for successive tasks. The findings thus provide general support for the hypothesis.

Although this study has primarily concentrated on establishing an understanding of the perceptual processes of the deaf and the relation of these processes to linguistic and reading competence, a more encompassing viewpoint should reveal profound but as yet abstrusive effects of a condition which prohibits individuals from regularly experiencing stimuli distributed in time. Visual and tactual stimuli can only serve to supplement the consequences of experiencing auditory stimuli if those who attempt to teach the deaf are prepared to provide their students with opportunities to experience visual-successive and tactual-successive stimuli as part of their educational schema.

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APPENDIX A

Instructions

The instructions to subjects, which follow, were signed to deaf subjects and spoken to hearing subjects.

"Hi, ----. My name is Barbara and this is my assistant, Patrick. We're going to play a little game. See all of these things around you? I'll tell you how they work. These are lights. See the flashes?"

Lights are flashed. Experimenter verbalizes or signs, "flash, flash, flash," with appropriate pauses between flashes. This arrangement was always used: flash-flash-pause-pause-flash.

"Now look over here."

Subject is directed to look at visual-simultaneous responses choices.

"See, there are three choices. You must find the one that is the same as the one I show you first."

Experimenter goes back to the lights and gives an example, then back to dots. Experimenter demonstrates manually or verbally that a particular temporal flashing arrangement is equivalent to the spatially distributed dot.

"They are same. 'Dot, space, dot, space, dot,' is the same as 'Flash, wait, flash, wait, flash.' Only

one of these," (experimenter points to choices 1, 2 and 3)
"will be the same as what you will see," (or "feel,"
depending on inspection-stimulus modality). "Two will be
different, okay? Now turn around," (subject is directed
to tactual-simultaneous response choice to his right).
"Put your hands in here, but look on top. Can you feel
the knobs? You see this part of the game has three
choices as well. This is number one, number two and
number three."

Experimenter directs subject's hands, from
opposite end, to explore the stimulus.

"'Flash, wait, flash, wait, flash,' is the same as
this," (as subject is directed to feel knobs and spaces
between the knobs).

"Okay? Now look at me. Patrick will put earphones
on your head. Are they comfortable? Raise your hand
when you can hear something." Appropriate decibel level
and frequency are determined.

"The buzzes are the same as the lights, the same
as the dots, the same as the knobs." Experimenter repeats
"Flash, wait, . . . etc.," manually while assistant relays
buzzes.

"I will hold up these cards," (experimenter
demonstrates by holding up cards with numbers, "1," "2"
and "3") "and you will tell me which one is the same as
what you will see," (or "feel") "first."

"Next, Pat will tap you on the back. Look at me. I will hold up these cards again and then Pat will tap you. The tapping is the same as the buzzes, the same as the knobs, the same as the dots, the same as the lights.

"Let's try the games."

Inspection stimulus is always given in a condition different than the one the subject will be presented with in the trials.

"Try to remember what you see," (demonstration).

"Now, which one is the same as what you saw? Do not give me an answer until you have seen" (or "heard" or "felt") "all three choices. Answer 'one,' 'two' or 'three.'

"That's right!" or "No, this is the correct answer." "Do you understand?"

If subject did not understand, a maximum of two more examples was given. If subject still did not understand, he was deleted from the sample.

APPENDIX B

Data Recording Sheet

SUBJECT_____ BIRTHDATE_____ AGE_____

TRIALS	CODE 1	PRESENTATION STIMULUS MODE	CODE 2	RESPONSE CHOICES		
1				O O O		
				O O O		
				O O O		
2				O O O		
				O O O		
				O O O		
3				O O O		
				O O O		
				O O O		
4				O O O		
				O O O		
				O O O		
5				O O O		
				O O O		
				O O O		
6				O O O		
				O O O		
				O O O		
7				O O O		
				O O O		
				O O O		